MODERN PLASTICS

mp

AUGUST 1942

Catalin LIQUID RESINS *transform* PLYWOOD *into* FLYWOOD!

Emerging from its cocoon of bandages which have held it to shape while receiving its "heat-cure", the glider tail-cone pictured above is fashioned from thin, lightweight mahogany veneers bonded into an inseparable whole by Catalin Thermosetting Resin Glue. It will not be affected by cold or boiling water, mold fungus, insects or exposure to weather.

Designed to play vital war roles, plastic-plywood planes and gliders are destined to become the passenger and freight transports of tomorrow. Not alone in the air, but on land and sea as well, woods laminated, impregnated, compregnated, bonded or coated with phenolic resin glues and varnishes will build homes and factories, automobiles and ships.

Catalin Liquid Resins are available in a wide variety of formulations—each developed to do some particular job superlatively well. They are used to create new materials and products of improved qualities from wood, paper, fabrics, leather, cork, glass and abrasives. "Catavar" Laminating Varnishes are heat-hardenable, while "Catabond" Bonding, Impregnating, Cementing and Glueing Resins come in hot, intermediate and cold-setting types.

Manufacturers, designers and engineers are invited to discuss their materials and production problems with our staff of technical experts. Whether for immediate or future application, they will be glad to advise on the use of any of Catalin's expanding family of modern plastics.

CATALIN CORPORATION

ONE PARK AVENUE • NEW YORK, N. Y.

"Catalin", "Catavar" and "Catabond" are registered trade marks

Featherweight Glider Seats and Tail-Cones are typical products of the ingenious, simple methods developed by the MARINE-AIR RESEARCH CORP. using Catalin Resin Glues.

Accurately cut to shape with a cutawl machine, 5 mahogany veneer plys form the glider seat . . . 7, the back.

Catalin Glues are applied in many ways. Most convenient for this type of production is by means of brushes, as illustrated.

When cut and glued, veneers are drawn over wooden form by means of laced canvas cover, then placed in rubber bag or under rubber sheet to effect uniform vacuum pressure.

While form is under vacuum pressure, boxlike device containing electric heating coils is lowered, developing constant heat sufficient to cure the resin and veneers into a rigid, molded unit.

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modern plastics

AUGUST 1942

VOLUME 19 NUMBER 12

SEPTEMBER

Low-pressure laminating has lately aroused considerable interest. John Nelson, member of the General Electric Plastics Laboratory Staff, which has been conducting extensive experiments with laminated materials, has written an article describing some tests made at room and elevated temperatures and the results which were obtained from them. This article will be a feature of the September issue.

One of the outstanding molded pieces produced by low-pressure methods was the helmet liner, described in our May number. Army headgear of this type is also being made by high-pressure methods. A story describing in detail this latter method of manufacturing, together with photographs of the assembly line, is being prepared for next month.

• GENERAL INTEREST

• TECHNICAL SECTION

• NEWS AND FEATURES

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"..information of aid and comfort to the enemy"

THE censor's stamp is, today, a badge of honor. The necessity of withholding information concerning a product implies its importance to the war effort.

How and *where* this censored new product is going to be used might be of particular interest to an Axis engineer in some far distant plant. It and many another, which cannot be described for the time being, were created by *Richardson Plasticians* for the sole purpose of speeding up the production of better, more effective equipment, in bigger quantities for the armed forces of the United Nations.

The use of INSUROK Precision Plastics and the many suggestions of *Richardson Plasticians* have helped war products producers save time and increase output. If the use of molded or laminated plastics might solve one of your problems, write us. We'll be glad to give you the benefit of our experience.

The Richardson Company, Melrose Park, Ill.; Lockland, Ohio; New Brunswick, N. J.; Indianapolis, Ind. Sales Offices: 75 West St., New York City; G. M. Building, Detroit.

INSUROK ***and the experience of Richardson Plasticians are helping war products producers by:***

1. Increasing output per machine-hour.
2. ✓ Shortening time from blueprint to production.
3. Facilitating sub-contracting.
4. Saving other critical materials for other important jobs.
5. Providing greater latitude for designers.
6. Doing things that "can't be done."
7. Aiding in improved machine and product performance.

INSUROK

BEFO' DE WAR

"A Ready Reference for Plastics" written for the layman, is now in a new edition. If you are a user, or a potential user of molded plastics, write us on your letterhead for a copy of this plain non-technical explanation of their uses and characteristics. Students and others 75¢ per copy—please!

THE advertising copy writer to-day is in a tough spot.

Everybody in the molding business is up to their necks in the war. It's nothing to boast about—it should be accepted as a natural condition as of to-day.

We are all making a lot of very interesting pieces—both in design and ultimate application—but we are not permitted to show pictures of them or tell about their uses.

Two years ago we ran this ad and were proud to boast of our participation in the development of the Scott Paper Cabinet—an advanced, constructive bit of pioneering in plastics. The time has long since slipped by when Scott could have material for this job. Without complaint they folded up the entire project and tucked it away for the duration.

Some time they'll be back—and thousands of other outstanding parts, no longer pioneering but accepted as the normal thing as a result of what we are all learning under war conditions.

Just engrave "PLASTICS" in your mental bring-up file, and then "BOONTON" alongside—the second is a great help to the first—not indispensable but a whale of a comfort.

BOONTON MOLDING COMPANY

MOLDERS OF PLASTICS · PHENOLICS · UREAS · THERMO-PLASTICS

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Here is the last word in Universal Testing Machines for the Plastics Industry. The Plastiversal was designed by Olsen to meet the specific needs of Plastics manufacturers and fabricators. Judging by the immediate response accorded it, this is equipment which fills a long-felt demand. Every detail has been engineered down to the last bolt on the recorder drum. Whether or not you have an immediate need for the Plastiversal, get the facts about it in Bulletin 23. A copy is yours for the asking.
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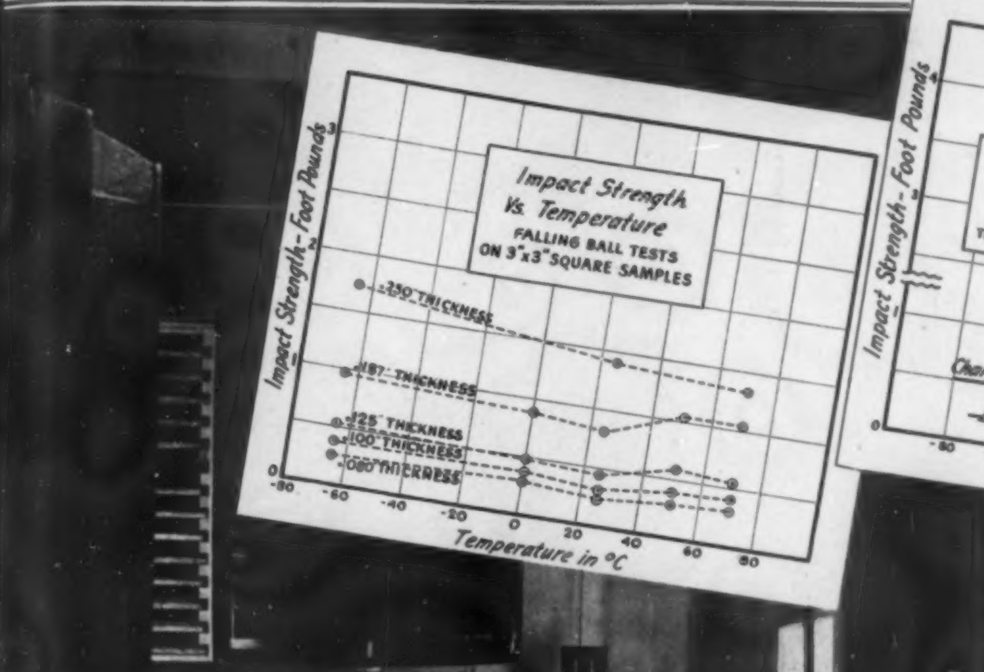
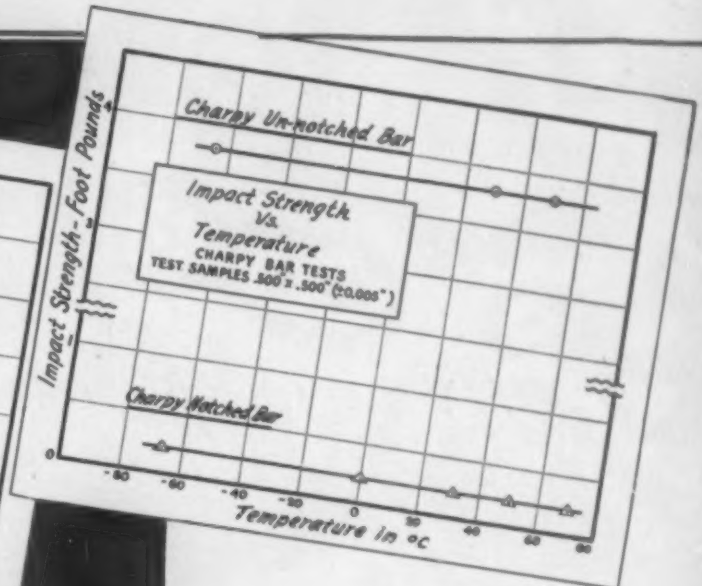
WOULD YOU GO BACK?

At temperatures far below zero

PLEXIGLAS RETAINS ITS HIGH IMPACT STRENGTH





The cold room in the new Rohm & Haas Physics Laboratory in which temperatures can be dropped to 60°F. below zero and wind velocity can be raised to 200 miles an hour.

TEN MILES in the air—when temperatures drop to 60°F. below zero—crews of America's fighting planes can still count on the strength and permanence of PLEXIGLAS cockpit canopies, nose enclosures, gun turrets, navigators' domes. At these low temperatures, where most plastics become dangerously brittle, the impact strength of PLEXIGLAS is as high as ever. This fact is confirmed by the results of three standard laboratory tests shown in the graphs above.

To approximate the conditions encountered by high altitude planes, Rohm & Haas has just constructed a cold room as part of its new Physics Laboratory.

In this room temperatures can be dropped to 60°F. below zero—40°F. below the temperatures at which frost normally ceases to form. Wind velocity can be raised to 17,000 feet per minute—roughly 200 miles an hour. Cabin pressures and humidities can be varied over wide ranges. Bullet impact, fatigue, deflection and other physical tests can be conducted.

By just such tests, our physics laboratories have built an impressive backlog of physical data on acrylic plastics. As pioneers in this field, Rohm & Haas has also had more than six years' experience in designing, fabricating and installing PLEXIGLAS parts. You can count on authoritative information, therefore, when you write Rohm & Haas, or ask a technical representative to call.

PLEXIGLAS is the trade mark, Reg. U. S. Pat Off., for the acrylic resin thermoplastic sheets manufactured by Rohm & Haas Co.

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA, PA.

Manufacturers of Leather and Textile Specialties and Finishes . . Enzymes . . Crystal-Clear Acrylic Plastics . . Synthetic Insecticides . . Fungicides . . and other Industrial Chemicals

Some Questions

on

Q. Does Nixon Ethyl Rubber absorb water?

A. Slightly in some cases, more in others. This can be controlled by formulation. White natural rubber absorbed more than most Nixon Ethyl Rubbers, black rubber absorbed less.

Q. How about dimensional stability in boiling water?

A. Some formulations stood up well in this test—about as well as natural rubber.

Q. How does Ethyl Rubber compare with natural rubber in abrasion resistance?

A. Ethyl Rubbers were far superior in this respect.

Q. Does Nixon Ethyl Rubber bounce?

A. Yes, but not as well as natural rubber.

Q. How about tensile strength?

A. Most Nixon Ethyl Rubbers showed greater tensile strength—as much as nine times greater—than natural rubber.

Q. Does Nixon Ethyl Rubber stretch?

A. Yes, in a ratio of about 1:4 with natural rubber. Ethyl Rubbers showed minor permanent deformation under stress at room temperature. Natural rubber showed none. At greatly reduced temperatures: −20° C. and −78° C. Nixon Ethyl Rubber showed its built-in flexibility.

Q. How good is the resistance of Ethyl Rubber to petroleum products and butter?

A. Better than natural rubber in many formulations.

THESE questions and answers are based on laboratory tests conducted with 35 different formulations of Nixon Ethyl Rubber. Each was formulated in different proportions with different plasticizers. Each behaved differently, indicating the formulating possibilities of this synthetic. Nixon Ethyl Rubber uses no solvents at all. It is tough, stable, pliable, flexible (even low temperatures) thermoplastic and resistant to mustard gas.

It is obviously a substitute for unavailable natural rubber in many applications. It can help fill the gap in rubber importation caused by the war.

It is made in any desired thickness over 10 mils. *The full results of the tests and samples of Nixon Ethyl Rubber will be sent to you on request.*

NIXON *Plastics*

NIXON NITRATION WORKS, INC., NIXON, NEW JERSEY

Mfrs: NIXON ACETATE MOLDING POWDERS • NIXONITE (acetate) and NIXONOID (nitrate), sheets, rods, tubes

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"O-I Plastics reflect . . . *the experience and resources of the developers of Duraglas containers . . . The World's Finest*"

PARTS MOLDED FOR DAYTON PUMP & MANUFACTURING CO., DAYTON, OHIO

THREADS IN PLASTICS

Close co-operation with our customer, plus equipment particularly adapted to the problem, made it possible to replace materials of a more critical type with these four plastic water pump parts.

Perfect threads is an old story to the Owens-Illinois Plastics Division because of the experience gained through molding many millions of threaded pieces. The satisfactory execution of these water pump parts indicates the facilities and experience applied to each job.

WE ARE EQUIPPED FOR:

Automatic Rotary Compression Molding

Injection Molding

Upright Compression Molding

Printing on Plastics

★

We operate 4 modern plants—Glassboro, N. J.; Gas City, Ind.; Toledo, Ohio; San Francisco, Cal.

Plastics Division... **OWENS-ILLINOIS**

TOLEDO OHIO

ETHYL CELLULOSE PLASTIC ... TOUGH at 70° below zero

(WAR SUPPLIERS PLEASE NOTE)

THESE ARE SOME OF THE WAR POSSIBILITIES OF ETHYL CELLULOSE PLASTICS

★ ★ ★

MOLDED: knobs . . . steering wheels . . . fittings . . . handles

★ ★ ★

EXTRUDED: on wire for insulation . . . tubing . . . strips . . . tapes

★ ★ ★

COATINGS: on fabrics for gas masks . . . raincoats . . . stratosphere suits . . . decontamination bags

Toughness—the inherent quality of Ethyl Cellulose plastic—is maintained at the maximum low-temperature specifications of the Army and Navy. Result of Hercules research, this plastic can be formulated to retain adequate flexibility at *minus* 70° F—and withstand sudden changes from very low to very high temperatures.

• • •

We urge you to investigate the applications of Ethyl Cellulose to your own war products. We do not make plastics, but can supply you promptly with full technical data, and refer you to the plastic fabricators who are formulating from Hercules Ethyl Cellulose.

★

HERCULES

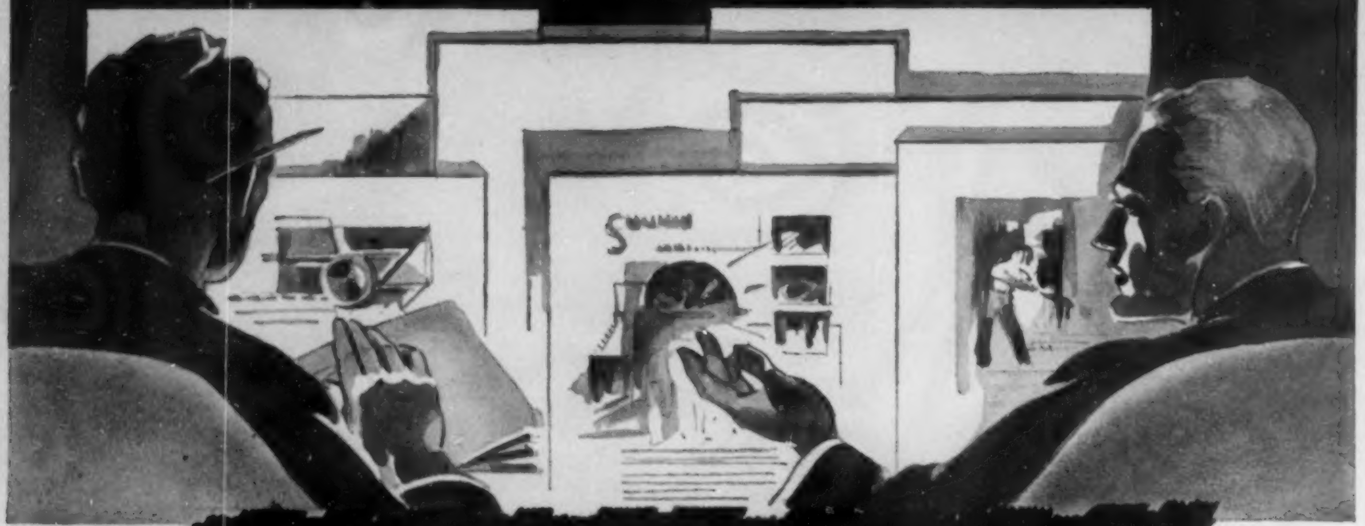
ETHYL CELLULOSE

★

HERCULES POWDER COMPANY · WILMINGTON, DELAWARE

"HOW DO WE KNOW?"

—*asked the President*



"WE INVESTIGATE BEFORE WE INVEST" — *said the advertising manager, and tells his President how the use of available facts protects their advertising investments.*

President: "That's a good looking campaign. The illustrations are stoppers. The copy is interesting and to the point. Now where do we go from here? How do we *know* that the publications in which we plan to run these ads are the best ones to do the job? And then how do we know that we get what we pay for? Or don't we?"

Advertising Manager: "We know because we investigate before we invest. Our choice of media is based on facts from reports issued by the Audit Bureau of Circulations, a self-governed association of advertisers, advertising agencies and publishers. Working with the publishers we have set up definite standards for circulation and provided methods and means for measuring and verifying the circulation of the publisher members.

"Take business papers for instance: A.B.C. reports show how much circulation a publication has, how it was obtained, how much people pay for it, where it goes, the percentage of renewals and other facts that make it possible for our agency to select the papers best suited to our needs and to tell us just what we will get for our money. When you see 'A.B.C.' after the names of publications on our advertising schedules, it means that our selection is justified by the verified information in A.B.C. reports."

President: "Good. That's the way it should be. Why hasn't someone told me these things."

SEND THE RIGHT MESSAGE TO THE RIGHT PEOPLE

Paid subscriptions and renewals, as defined by A.B.C. standards, indicate a reader audience that has responded to a publication's editorial appeal. With the interests of readers thus identified, it becomes possible to reach specialized groups effectively with specialized advertising appeals.

MODERN PLASTICS

Member of the Audit Bureau of Circulations ABC ***Ask for a copy of our latest A. B. C. report***

A. B. C. = AUDIT BUREAU OF CIRCULATIONS = **FACTS** AS A MEASURE OF CIRCULATION VALUES

IT'S a great relief, when you place your plastic fabricating order, to know that your job is being taken care of efficiently, promptly and with proper expediency. Ask us, we know! Because many a tough, "impossible" job was brought to us after the other fellow turned it down or failed to deliver.

That's why we say, for smooth sailing, bring your fabrication job to us.

INJECTION MOLDED PARTS
EXTRUDED SHAPES
FORMED ARTICLES

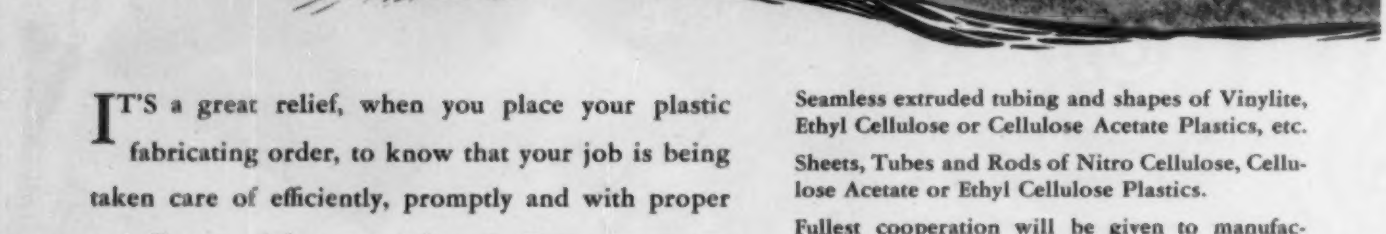
Seamless extruded tubing and shapes of Vinylite, Ethyl Cellulose or Cellulose Acetate Plastics, etc.

Sheets, Tubes and Rods of Nitro Cellulose, Cellulose Acetate or Ethyl Cellulose Plastics.

Fullest cooperation will be given to manufacturers with high priority ratings requiring the above materials.

Inquiries invited.

THE Insel COMPANY
ARLINGTON, N.J.

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INJECTION MOLDING MACHINES

BEHIND THESE DOORS THINGS ARE HAPPENING IN PLASTICS!

CHICAGO MOLDED PROD. CORP.
CMPC

COMPRESSION
INJECTION
TRANSFER
EXTRUSION
MOLDING OF ALL
PLASTIC MATERIALS

★ These are the doors to the largest and best equipped custom molding plant in the Middle West. Until a few short months ago, they have always opened hospitably to all who came to inspect or to learn. Now, and for the duration, they must be closed to all but our working force.

Yet, behind these doors, progress in plastics goes on—at a stepped-up pace, set by the grim determination to win. We're building bigger and better molds than ever before, and we're building them faster. Our battery of presses is setting new records for production. And while in the past we have welcomed the difficult molding jobs, we are now turning out still more difficult pieces—more than ever accomplishing the things that "couldn't be done."

It goes without saying that every step in this progress, as well as all the skill and productive capacity we possess, is concentrated on the vital task before us—producing goods to win this war. But, when the last shot has been fired, and American industry turns again to the problems of peace, the developments now taking place behind these doors will be available to you as potent weapons in the struggle to regain peacetime markets.

So if you are among those planning ahead for peace while producing at top speed for war, let us plan ahead with you. For competitive markets, like wars, are won by those who are best prepared.

CHICAGO MOLDED PRODUCTS CORP.
1020 NORTH KOLMAR AVENUE CHICAGO, ILLINOIS

New Target for Industry:

More Dollars Per Man Per Month in the
PAY-ROLL WAR SAVINGS PLAN

TO WIN THIS WAR, more and more billions are needed and needed fast—AT LEAST A BILLION DOLLARS A MONTH IN WAR BOND SALES ALONE!

This means a *minimum* of 10 percent of the gross pay roll invested in War Bonds in every plant, office, firm, and factory in the land.

Best and quickest way to raise this money—and at the same time to "brake" inflation—is by stepping up the Pay-Roll War Savings Plan, having every company offer every worker the chance to buy MORE BONDS.

Truly, in this War of Survival, VICTORY BEGINS AT THE PAY WINDOW.

If your firm has already installed the Pay-Roll War Savings Plan, *now is the time—*

1. To secure wider employee participation.
2. *To encourage employees to increase the amount of their allotments for Bonds, to an average of at least 10 percent of earnings—because "token" payments will not win this war any more than "token" resistance will keep the enemy from our shores, our homes.*

If your firm has not already installed the Pay-Roll War Savings Plan, *now is the time to do so.* For full details, plus samples of result-getting literature and promotional helps, write, wire, or phone: War Savings Staff, Section E, Treasury Department, 709 Twelfth Street NW., Washington, D. C.

U. S. War Savings Bonds

This space is a contribution to America's all-out war program by

MODERN PLASTICS

MODERN PLASTICS

AUGUST 1942 VOLUME 19 NUMBER 12

Extruding vinylidene chloride*

PREVIOUS articles appearing in these pages have discussed vinylidene chloride plastic in relation to its use for unoriented extrusions such as tubing and injection moldings.[1] Since these have included rather complete descriptions of the base resin and its properties, a brief summary will suffice for the purposes of this paper.

General properties

The raw materials for the resin are obtained from petroleum and natural brines which are converted to monomeric vinylidene chloride. It is a colorless, odorless, tasteless, non-toxic liquid which boils at 31.7° C. and exhibits the structural formula $CH_2{=}CCl_2$.

Polymerization of this monomer produces the long, linear, straight chain polymer—CH_2—CCl_2—CH_2—, polyvinylidene chloride.[2] Variations of polymerization and copolymerization result in a group of related resins with somewhat different properties. Thus it is possible to obtain materials ranging from the soft and flexible with a softening point around 70° C. to the hard, rigid and tough with a softening point of at least 180° C.

Not all of these, however, are commercially offered at present. The standard polymer now available is a thermoplastic solid with a softening point of approximately 120° C. to 140° C. and having a molecular weight of about 20,000. The base resin, like its monomer, is tasteless, odorless and non-toxic. When fabricated, it exhibits great toughness, abrasion resistance and flexural fatigue life. It shows outstanding resistance to water, acids, alkalies and most organic solvents. The retention of these properties on aging insures long life and satisfactory performance under hard service conditions. The material has a high refractive index and extensive color possibilities—both factors which contribute to appearance value. Being self-extinguishing, it presents no fire hazard.

Extrusion equipment

While in general the techniques for the extrusion of the fibers closely follow those already established for the fabrication of other plastics by this method, slight modifications in standard extrusion equipment are required. These have been worked out carefully and completely by technical men in close cooperation with machine manufacturers to ensure that fabricators of the material obtain the proper equipment.

The screw type extrusion unit is used, but the cylinder and screw are shorter than those commonly employed for other plastics. Designs permitting streamline plastic flow are desirable. Since the plastic has an extremely low heat transfer rate, it is recommended that clearances between the torpedo and torpedo housing be somewhat less than those considered standard, in order to ensure thorough plastification in the hot zones.

Iron and copper base metals catalyze its thermal decomposition at temperatures above 130° C., and other suitable metals are required for heated sections which come into direct contact with the plastic. The forcing screw, the surrounding cylinder housing, the torpedo and torpedo housing, the elbow and the die should be made of Hastelloy and Stellite. Magnesium and nickel and nickel base alloys have been found satisfactory.

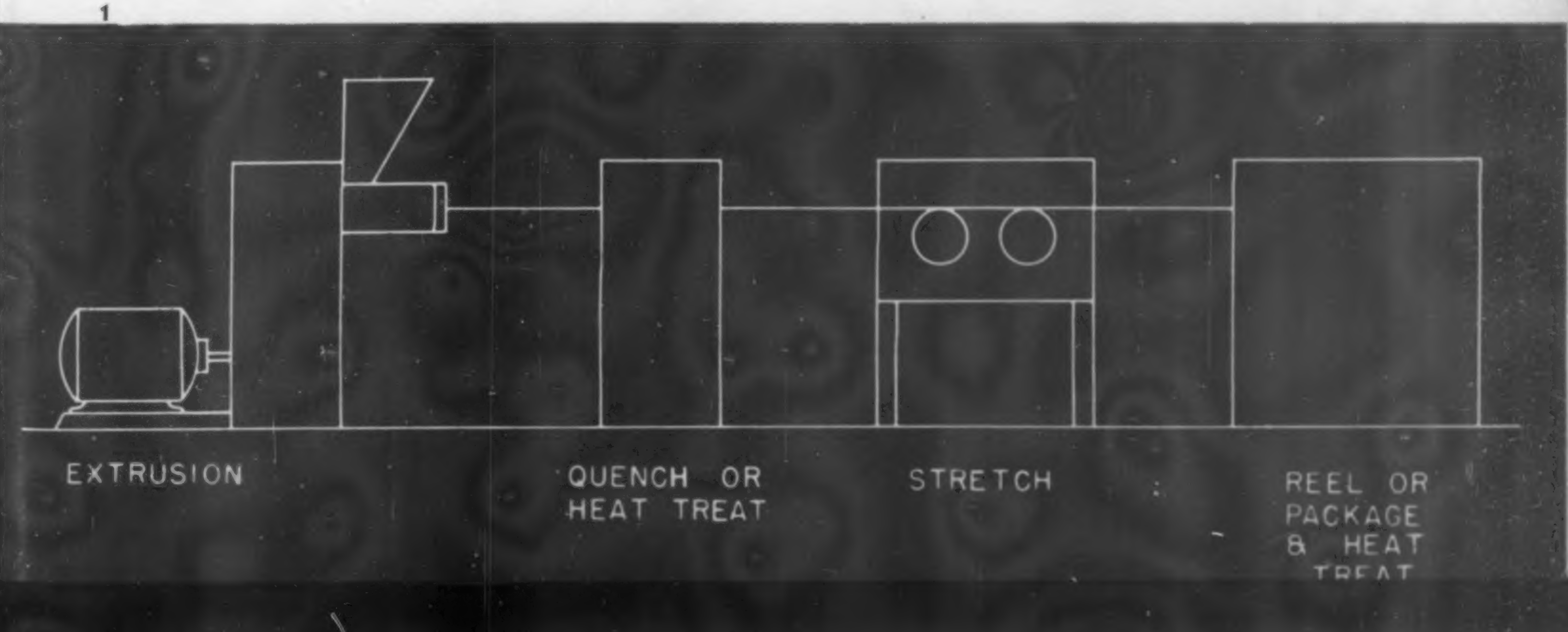
Extrusion operation

The extrusion of the plastic fibers includes supplying a uniform rate of feed to the screw machine hopper, mixing

* This article was especially prepared for MODERN PLASTICS by Dow Chemical Co.
[1] MODERN PLASTICS *19*, May 1942, p. 64.
[2] The products sold under the trademarks or trade names Saran, Velon, Mills Plastic and Fibron are composed basically of polyvinylidene chloride. All the copolymers and polymers covered by the name Saran are manufactured by Dow Chemical Co.

1—Crystal orientation of vinylidene chloride fibers is obtained by cooling, stretching and reheating the amorphous plastic. Production of uniform high quality extrusion is maintained under carefully controlled operating conditions

1



PHOTOS, COURTESY FIRESTONE TIRE & RUBBER CO.

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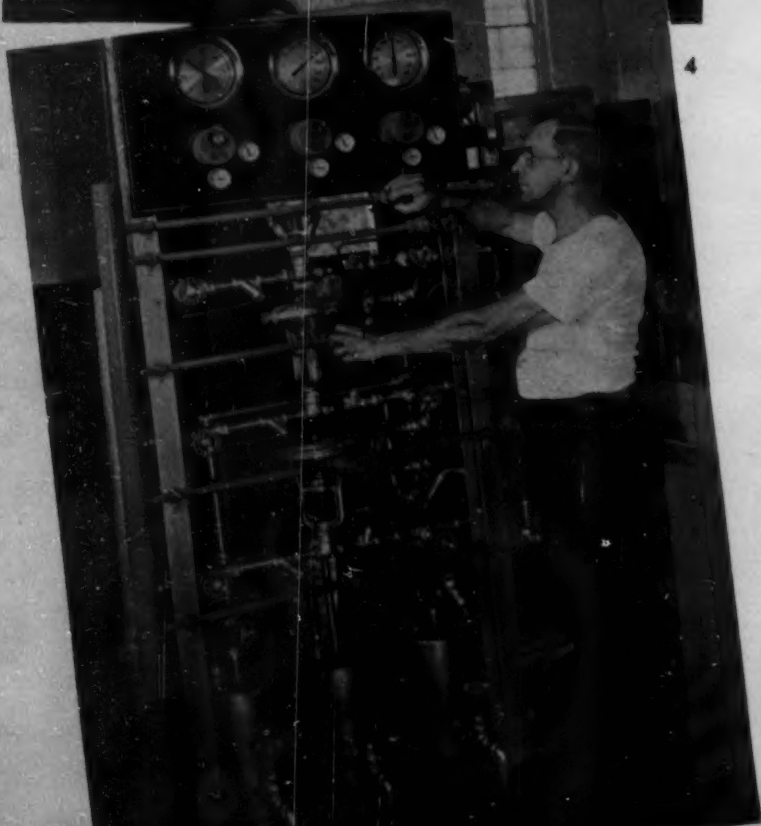

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2—Five screw-type extrusion units are kept busy producing vinylidene chloride fibers into thread prior to weaving. 3—The plastic in powder or granule form is placed in a hopper, whence it is fed into a heating chamber where it is liquefied under heat and pressure. A uniform rate of feed is essential. 4—A battery of steam gages controls temperature and pressure of steam in the extruding units where plastic crystals are mixed, melted and forced through extrusion dies in semi-liquid state before conversion to thread

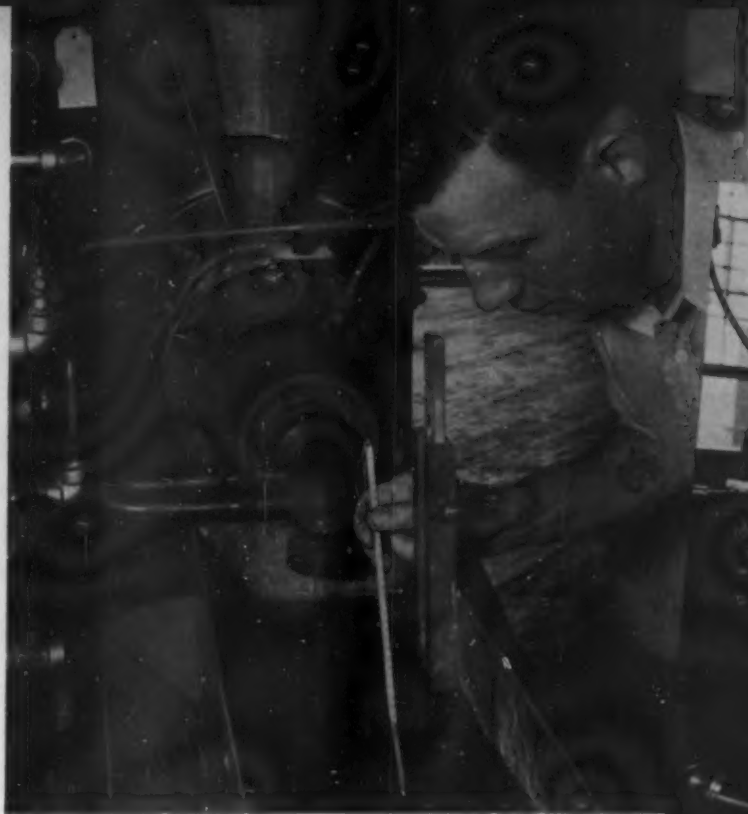
and heating the plastic as it is forced along by the screw and then forming it as it passes through the die. The extruded shape may be cooled and subsequently heat treated.

The plastic is usually fed to the unit as a powder, but granules may be used also. The former, being less bulky, is considered more convenient in most cases. It is also less expensive than granular feed, which requires another operation to prepare. A uniform rate of feed from the hopper is essential. To secure this, agitation devices are used on the larger machines. The revolving paddle-wheel type of feed, however, is preferred for the smaller units.

Thorough melting is of prime importance in the successful extrusion of the vinylidene chloride fibers. To accomplish this, the material is passed through four jacketed zones. The first, or the point at which the powder enters the machine, is kept cool by the circulation of cold water to prevent the powder from becoming sticky and clogging the feed box chamber.

The next three are the hot zones where plastification takes place and these areas represent the critical phase of the operation. Since this plastic has a sharp softening point and is susceptible to overheating, it is necessary to pass it through these zones as rapidly as is consistent with thorough mixing and melting. To this end the heat zones in the unit are designed to handle a smaller volume than ordinary and the flow of the plastic through them and the dies is streamlined.

The second, or preheating, zone operates at relatively low temperatures, and here the powder is partially plastified before entering the third, or high heat zone. This is neces-



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5—Operator tests temperature of water bath, maintained at even degree, before extruded plastic, still in semi-liquid state, is plunged into it. This process temporarily "fixes" the state, and at this point the thread is actually created. 6—Operator tests "pull" of thread as it comes off last of four dies, over which it has been stretched 4 to 1, almost to its elastic limit. 7—Here the thread is being rewound on shipping spools from which it is finally woven into the fabric

6

sary to reduce the time required for the polymer to remain in the hot zone.

In the fourth zone, only sufficient heat is maintained to keep the plastic in a fluid condition. The fused material leaves the die in a very fluid state and subsequently must be cooled to retain the shape and finish of the section. This is usually accomplished by means of a water bath maintained just below room temperatures.

Orientation

Due to the fact that the plastic shows definite crystal structure at ordinary temperatures and that this crystallite arrangement can be controlled to a certain degree, the properties of the extruded section depend in part on the treatment it receives after leaving the die. When first heated above its crystallite melting point, extruded and cooled, the product is in an amorphous state similar to that of most other plastics and exhibits comparable characteristics. At room temperature it will gradually harden, and recrystallization will occur at a slow rate with a resultant random arrangement of the crystals. The rate of recrystallization, however, is a function of the temperature and can be regulated from a few seconds to several weeks.

Through such controls a range of properties may be obtained. For example, tensile strengths may be varied from 4000 lb./sq. in. to 12,000 lb./sq. in., hardness from 60 to 95 (Rockwell Superficial 15y), elastic elongation from 10 to 40 percent. Because of the random crystal arrangement of

7

8

products produced by these techniques, they are known as *unoriented extrusions*.

Crystal orientation, accomplished by mechanically stretching the plastic before complete recrystallization takes place, brings out improved properties in the finished material. This method is particularly adaptable to the production of continuous extrusions of monofilaments, tapes and similar type shapes and gives them exceptional characteristics.

To produce oriented sections, the plastic is first heated above its crystallite melting point, next formed to the desired shape, subsequently cooled and finally elongated under controlled conditions. The first two of these steps have been described above, but a description of the last two will help to clarify the operation.

Cooling is accomplished by passing the hot, formed plastic as it leaves the die through a water bath maintained at controlled temperatures. This operation retards the rate of recrystallization, allowing the material to remain in the amorphous state sufficiently long to permit the cold working operations of orientation to be carried out.

This process (Fig. 1) deforms the amorphous plastic by means of stretching rolls operating at different rates of speed, while partial recrystallization takes place. The crystallites are thus oriented along the major axis of the strand. The reduction in cross sectional area is approximately proportional to the elongation which takes place, usually 300 to 400 percent. Heat treatment, either during or after the stretching, affects the degree of crystallization, and thus offers a further control of the properties of the oriented section.

Extruded and oriented shapes

The above method produces orientation in a single direction with the resultant uni-directional properties of high tensile strength, great flexibility, long fatigue life and good elasticity. These are particularly desirable in monofilaments where the load is along the longitudinal axis. In other sections, such as tapes, where transverse orientation is equally important, a rolling operation following the quenching step may be established. This will in nowise interfere with the continuous nature of the process. (*Please turn to page 122*)

9

8—Interior view of the extruding plant with several extruding units shown in background. Note rewinding machines, center, with shipping spools stacked close by. 9—Final adjustment is made on weaving machine before the fabric is run. The plastic thread is woven into a variety of multi-colored patterns and designs on these machines

COLOR PLATES, COURTESY FIRESTONE TIRE & RUBBER CO.

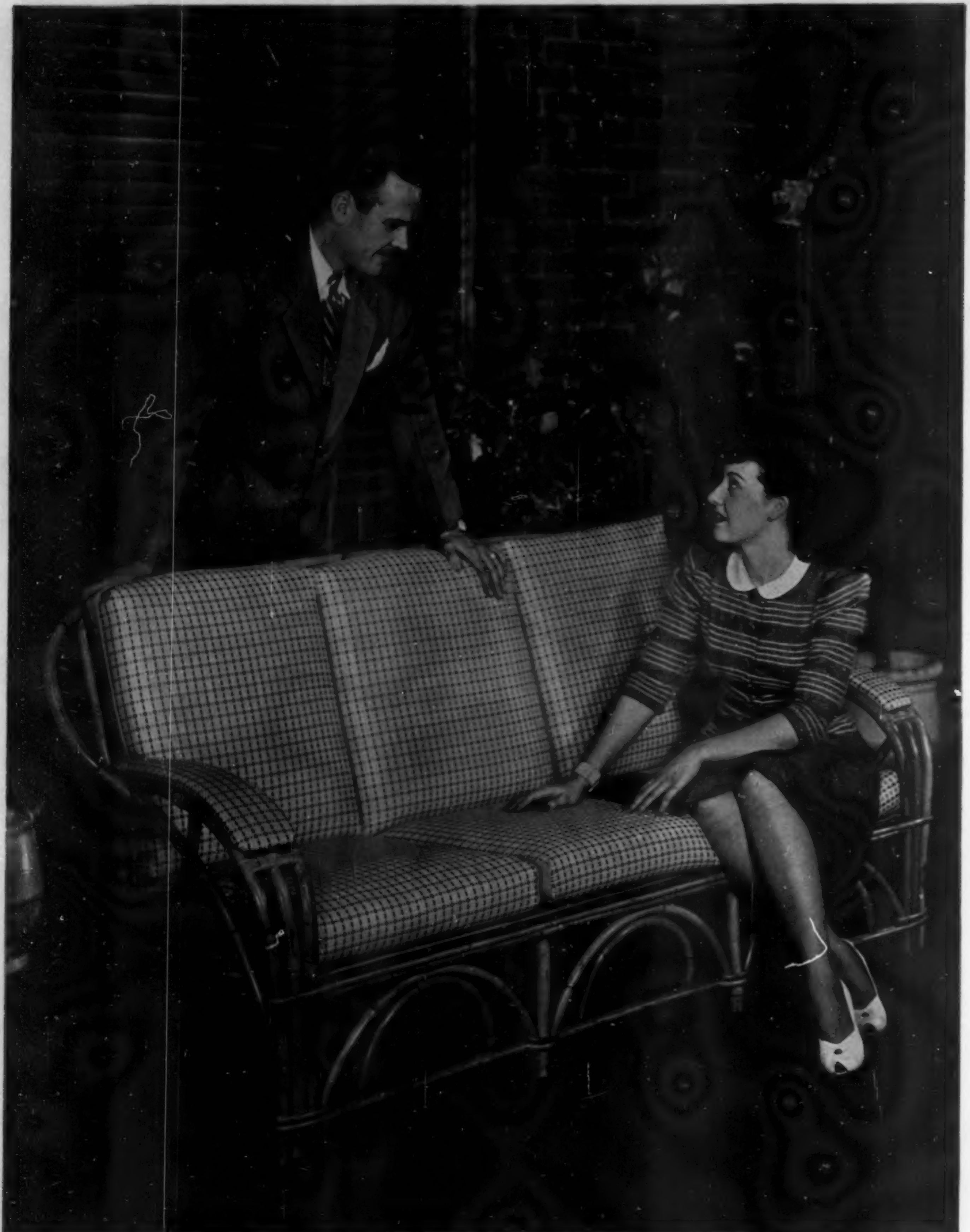
A blaze of vivid color in a length of fabric woven from extruded fibers of vinylidene chloride resin suggests the infinite variety of color and design possible. The new plastic cloth is suitable as upholstery for home furnishings, bus, subway and theatre seats

Fabrics of the future*

AN overturned ink bottle streaking the spanking newness of the living room sofa; a blob of grease sullying the automobile upholstery; unsightly rain and dust spots defacing the beauty of brightly hued draperies—each of these accidents spells one of life's darker moments for the average householder. But the time is almost here when such a mishap will be regarded with cool indifference by the most fastidious housekeeper. The reason? A new plastic fabric woven like cloth from extruded fibers of vinylidene chloride,† endowed with the abundant advantages of flexibility, resilience, resistance to stains, alkalis, acids, etc., which is now being perfected, and which is slated to reach the consumer market in an extensive span of applications in short order. The advantageous physical properties of this new development, its remarkable response to simple cleaning methods, and its widespread adaptability to a multitude of varied uses presage for this new cloth an increasingly significant rôle in our war-conscious economy that will be sustained and broadened during the postwar period.

This woven fabric is extraordinarily tough and resistant to abrasion. It will not support sustained combustion; and although it will char if exposed to a direct flame, it will not burn readily, and is described as being capable of withstanding a temperature up to 170° F. It is reported to possess excellent aging qualities, and to have extremely low water absorption. One experiment provided for immersion of a piece of the cloth in water for a 24-hr. period. At the end of the

* This article was especially prepared for MODERN PLASTICS by the Firestone Tire & Rubber Co.
† Articles fabricated of Saran by the Firestone Tire & Rubber Co. are known by the trade name Velon.



COLOR PLATES COURTESY FIRESTONE TIRE & RUBBER CO.

Tableau on the terrace with an inviting plastic sofa for background. Woven of extruded fibers of a vinylidene chloride composition into a colorful jacquard pattern, the upholstery is not only cool and pleasing to the touch, but smooth, flexible and extremely durable. The non-porous quality of the material confines dirt to the surface so that soil and stains may be whisked off in a twinkling

specified time, no perceptible change in the sample tested could be observed. So much for the practical aspects of this new development. On the aesthetic side it might be recorded that practically every hue and color of the spectrum are available in this new fabric, and the range covers all of the possibilities from the transparent to the opaque. Perfected looms and improved weaving methods make possible unlimited varieties of patterns and design, so that versatility and interest may be woven right into the fabric from the beginning.

Today this new fabric is already in limited use as upholstery for furniture, automobiles, buses, trucks, airplanes, trains, street cars and other transportation units subject to constant and unremittingly tough service conditions. As automobile upholstery, or seat covering for station wagons, trucks, buses, taxis and other public and private conveyances where ordinary fabrics are soon rendered ugly and disreputable-looking by the combined onslaughts of sun and rain, grime and dirt, and constant hard use, this new fabric is reported to retain its original beauty and brightness indefinitely. Dirt, rain, sun, acids, oils, grease, chewing gum—all of these enemies are either powerless to affect this plastic cloth, or may be rendered harmless simply by applying the homely remedy of soap and water, or using any ordinary cleansing fluid.

For institutional use, in hotels, restaurants, theatres, and hospitals, where cleanliness and beauty are factors of prime importance, this new cloth with its special properties would seem to be peculiarly advantageous. One of the major expenses in hotel management is frequent redecoration necessitated by the wear and tear on upholstery fabrics, draperies and wall coverings which yield to time and the elements by becoming limp and lack lustre after an interval of use. With this new plastic fabric, not only is a wider and more colorful selection of fabrics and textures possible, but the expense of redecorating from year to year is eliminated. Careless guests and unavoidable accidents which result in spattered food and spilled liquor present another acute problem to hotel and restaurant management. Again, soap and water or ordinary cleaning agents will repair the damage.

In restaurants the upholstery, which must be kept bright and attractive under all conditions, is constantly exposed to the hazards of food and beverage mishaps. Here, too, this new fabric makes a very desirable medium for seat coverings in a wide range of color and weave possibilities.

In this country of inveterate movie-goers, theatre-seating presents probably the greatest potential market for this new development. More than 16,000 theatres throughout the country with a seating capacity of 10,000,000 persons are in daily operation. Theatre seats receive hard and constant wear; and extensive replacements necessitated by deterioration of weakened fabrics, ripping and tearing of materials, etc., cut deep into the profits of small and large scale operators alike. To offset high maintenance costs, many theatre owners resort to harsh, unattractive seating materials which are not only difficult to keep clean, but are uncomfortable in the summer despite air-conditioned interiors. The plastic fabrics will make possible long-term economy because the handsome, sturdy materials will save thousands of dollars in replacements and maintenance, while providing clean, sanitary seating facilities for patrons. Vandalism, with the theatre seat serving as a secluded repository for chewing gum, candy and other refreshments, is another bane of the movie management's existence. Ordinary fabrics will almost never yield

PHOTO, COURTESY DOW CHEMICAL CO.

In this modern chair, the versatile fibers of vinylidene chloride resin assume a rattan-like appearance, one of a wide variety of weaves possible

chewing gum once it has taken hold but, with a minimum of elbow grease, any cleaning fluid will dislodge it.

For hospital waiting, examination and operating rooms, where sterilization and antiseptic cleanliness are of paramount importance, and bright colors impart a psychologically effective note of cheer, the long-wearing qualities of the material and its resistance to chemicals will be invaluable assets, as will its inhospitality to vermin and germs.

Experiments now underway point to increasingly widespread and diversified uses for this new material. Consider the homemaker's pleasure in a bright, non-porous, durable, easily cleaned fabric, suitable for use in living room, dining room, kitchen, bath, playroom porch, lawn, or nursery! Combined with other fabrics such as cotton or rayon, unique and attractive drapery fabrics can be designed. For the ingenious housekeeper, this fabric represents a decorator's dream come true.

The apparel designer will also recognize in this newest of plastic developments a long-sought-for medium for a variety of accessories, everything from hats, handbags and belts, to gayly hued evening slippers and children's play shoes.

The double-barreled task of providing our armed forces with materials of war while new and improved production is kept rolling on the home front is a responsibility that the plastics industry is sharing with all industry in this country today. The development of this new plastic material will go a long way toward releasing cotton, wool, rayon, silk, paper, even rubber and leather for direct war uses.

Credits—Material: Saran, Dow Chemical Co.; Velon, Firestone Tire & Rubber Co.

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1—A tube and two end plugs comprise the smaller machine gun ammunition box roller. 2—The larger feed chute roller has two wheels cemented to the shaft. Both are of wine-colored transparent cellulose acetate butyrate, are light and wear-resistant

Molded ammunition rollers

by CARL MARQUARDT*

"KEEP 'em flying," when supplemented by "keep 'em firing," spells a fighting plane in action. Add "keep 'em rolling," and you have the cartridge belt slipping smoothly and swiftly over its rollers, carrying cartridges from the ammunition box to the gun. If the plane is a new Curtiss P-40, carrying .50 calibre machine guns, the ammunition box and feed chute rollers will be of molded cellulose acetate butyrate. Carefully engineered, produced and assembled, these plastic rollers contribute no small part to the precise functioning of the plane's armament.

The background for the use of injection-molded thermoplastic parts in Curtiss planes is outlined by C. G. Trimbach and P. F. Rossman, of the company's engineering department, who write:

"Through newspaper and Government publicity the need of conservation of strategic materials and their restriction for non-defense purposes has been brought to the attention of all citizens. In order to avoid leaving the impression that the conservation of material applies to civilian uses only, the Curtiss-Wright Corp. has, from the very beginning of the emergency and in fact prior to it, embarked upon a program of substituting materials whether or not they are in the critical list.

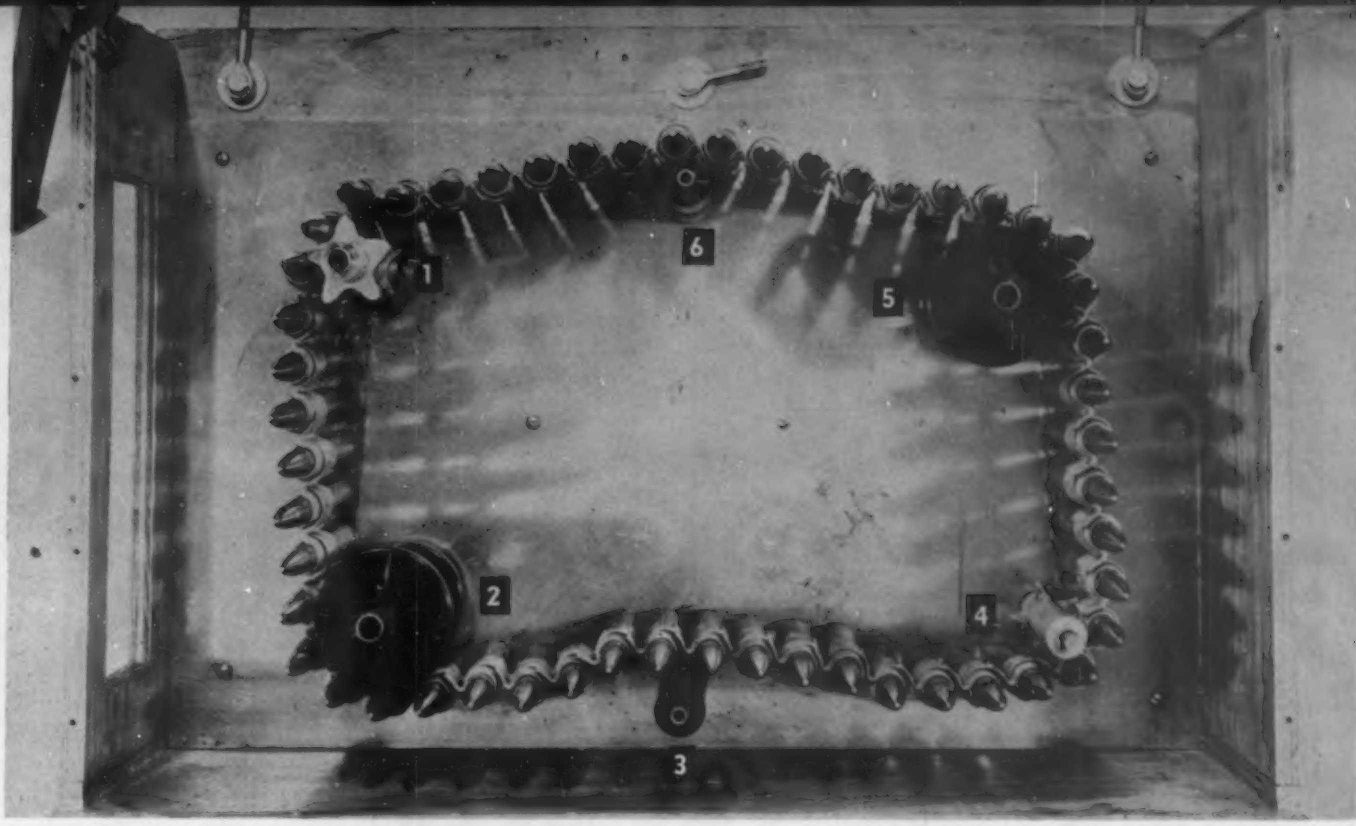
"This was done not only to expedite production because of the possibility of material shortages but, in many cases, to produce a better product with more uniformity and greater interchangeability to facilitate aircraft production.

"It is not to be construed that the substitution of materials always is concerned with changing from metals to nonmetals . . . a phenolic fiber ammunition belt roller is replaced with an injection molded plastic part. Because of the nature of the plastic, besides reducing the weight by the judicious employment of ribs, the roller is also made in two parts and cemented together. The resulting substitution not only was considerably lighter but it released the use of phenolic materials for other purposes. Besides reducing the weight of the plastic part by appropriate webbing, there is an additional advantage in the injection molding method in that when sections are thin—that is, a thinness compatible with strength—a skin effect is obtained in the plastic. The skin effect results in a high strength and a resistance to wear. By the use of plastic in place of phenolic fiber, a 20 percent reduction in weight is realized. Another disadvantage overcome by the use of the plastic roller was that the inertia of the part was considerably reduced. This is an important consideration in that, in order to achieve a free and responsive movement of the ammunition belt, the rollers must start instantaneously without lag and not cause the ammunition to slide over the roller with incident wear.

"These material substitutions also have taken into consideration the use of subcontractors from industries not associated with aircraft production; for example, woodworkers, metal furniture workers and plastics industry workers have been used. Curtiss-Wright has not restricted the knowledge gained and is giving this information as a whole to other manufacturers. Items of approved design are being submitted to the Aircraft Standardization Committee for use by other companies. Furthermore, Curtiss-Wright welcomes inquiries from other manufacturers regarding these items and additional information can be obtained by the necessary authorizations."

The most interesting feature of the molded rollers is the

* Sterling Injection Molding, Inc.



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3—*Set-up for service test given the rollers to determine wear or breaking at extreme temperatures. Two samples of each type of roller were tested. Nos. 1 and 4 are aluminum alloy rollers; 2 and 5, feed chute rollers; 3 and 6, small plastic rollers.* 4—*Rollers at the end of tests equivalent to 320, 725 rounds of ammunition. Scratches on small rollers were made by edges of metal cartridge links, did not affect their serviceability. Metal rollers showed equal wear*

method used to mold the tubular sections of the assemblies. Water cooled cores operating from both ends of the cavity and dowelled to meet and lock formed the molded hollow tube. This method was used in order to avoid the long core pull which would be necessary if the cores were not so constructed. The molding operation was successful, even though the inside of the tube showed a slight flash where the cores met.

Cellulose acetate butyrate was selected because it is qualified to meet the extremes of temperature range specified (−40° F. to 160° F.). H-2 flow was accordingly required. This resulted in considerable mold shrinkage, which was easily overcome by minor mold changes.

The customer's engineers selected a wine colored transparent thermoplastic in order to distinguish the parts readily. The transparent assembly can be quickly inspected, and defects in material or construction cannot easily go undetected. With such defects eliminated, plant inspection can be limited to scrutinizing parts for molding and assembling accuracy. Of more than one-quarter million pieces molded, less than 1/2 of 1 percent have been returned for slight dimensional correction. Final rejections from the large quantity produced to date are nil.

Wearing qualities of the plastic parts may be judged from Fig. 4, which shows the rollers after 4 test runs of 320,725 equivalent rounds of ammunition. Marks of wear on the small rollers (Nos. 3 and 6) were caused by the sharp edges of the metal cartridge links, and did not affect their serviceability. The same degree of marking can be seen on the aluminum alloy parts (Nos. 1 and 4).

Tests made at the Curtiss-Wright (*Please turn to page 124*)

PHOTOS, COURTESY CURTISS-WRIGHT CORP.

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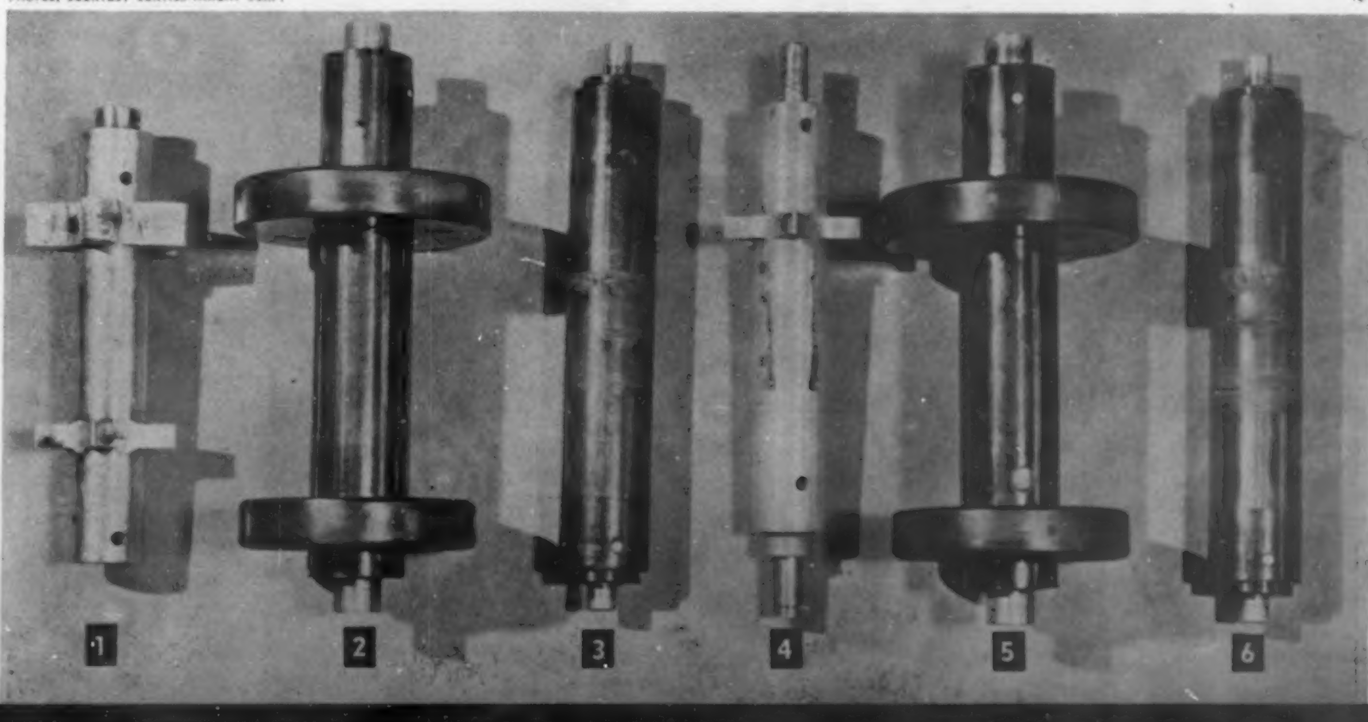

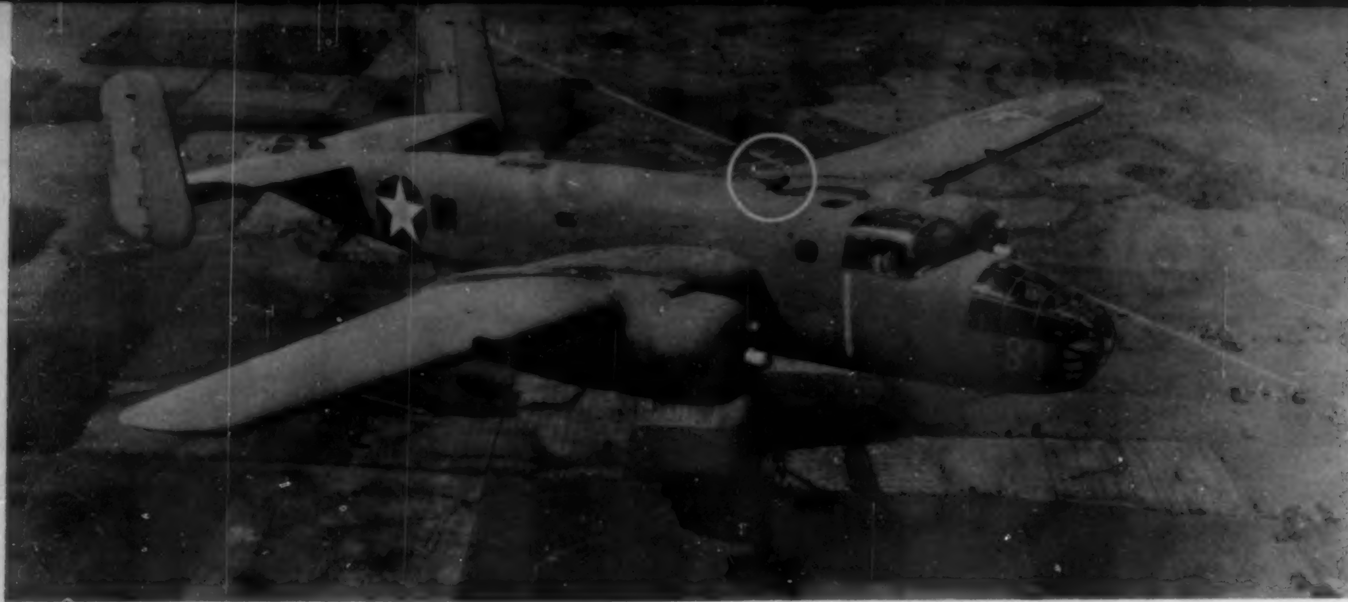

OFFICIAL PHOTOGRAPH, U. S. ARMY AIR FORCES

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1—*Deep, square body, narrow diamond wings, split tail spot the North American B-25 medium bomber, as any airminded child can tell you. Spotted here: its fabric-filled phenolic loop antenna housing*

Tokyo and return

by H. M. RICHARDSON*

PERCHED on top of the fuselage of the North American B-25 bomber that Jimmy Doolittle flew from Shangri-La to Tokyo was a small tear-shaped object, plainly visible in the photograph above, but very likely unremarked by the startled Japanese. On almost all of the big American bombers—those now in the air and those yet to come off the assembly lines—will be found the same tear-shaped plastics loop antenna housing.

The new use of plastics in this application is one of the most interesting the war has stimulated, and the history of the housing in terms of the problems met and overcome involves all the divisions of the plastics industry. There were, in order: the search for raw materials; questions of design and engineering; problems of moldmaking and difficulties of molding. The whole story of the plastics unit goes even beyond these technical aspects and into the field of human psychology.

Formerly, the loop antenna of the U. S. bomber's radio communications system was housed in a wood frame covered with cloth. The entire housing was held together with an adhesive. This construction possessed obvious disadvantages. Production was costly and slow and did not lend itself readily to the greatly increased output required by our expanded military program. Furthermore, the finished product was brittle, and did not stand up too well under the terrific beating it took from wind, rain, ice, snow, sun and extremes of temperature.

When the change to a molded plastics housing was suggested and developmental work began, the teardrop shape obviously dictated a housing which could be split either lengthwise or across and molded in two sections. Several years ago, a plastics housing had been designed and molded with a lengthwise split; and holding the dimensions for a tight fit of the two halves had proved troublesome because of warpage and shrinkage. Therefore, the crosswise split was selected, in the belief that it would give the following advantages: 1) There would be less chance of the housing getting out of alignment during assembly; 2) the assembly job itself would be less difficult; and 3) warpage and shrinkage would be considerably lessened.

However, this choice presented a difficult molding problem. Since each of the two molds would have a deep cavity and long plunger (see Figs. 4, 5), a compound would have to be

* Chief engineer, Plastics Dept., General Electric Co.

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PHOTOS. COURTESY GENERAL ELECTRIC CO.

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selected and a molding cycle established which would produce pieces that were fully filled out and of uniform density. It was also necessary to design a mold with sufficient support and guidance for the plunger to maintain good alignment. Further, the molder had to distribute the compound skillfully in the mold cavity before closing the press.

The housing had to be made of a fabric-filled phenolic compound to provide the required combination of strength, toughness and weather resistance necessary to meet the extreme temperature, humidity, pressure and erosion conditions to which it would be exposed when mounted atop the fuselage of a high-speed plane. At the same time, the material had to have the right balance between plasticity and speed of cure to flow properly throughout the deep-draw mold and give uniformly strong, dense parts. The phenolic compound chosen to do this job uses a special grade of filler which, incidentally, is a by-product of the war effort since it is a very high quality cotton twill obtained from the (*Please turn to page 134*)

5

2—Smooth, streamlined, the completed housing looks like a mammoth silver teardrop. 3—Tail (left) and nose of housing as they come from the mold, showing studs and lugs for assembling. Pedestal attaches to opening in nose. 4—Plunger for tail of housing must be expertly polished with fine pumice. Its long throat keeps the mold lined up. 5—Press plunger rises with a molded housing nose, ready for removal. Drum of phenolic compound is in foreground. 6—In the finishing room, housings are assembled, sanded and roughed. 7—An alkyd-type paint sprayed on the housing adds protective qualities, serves as a basis for camouflage paint

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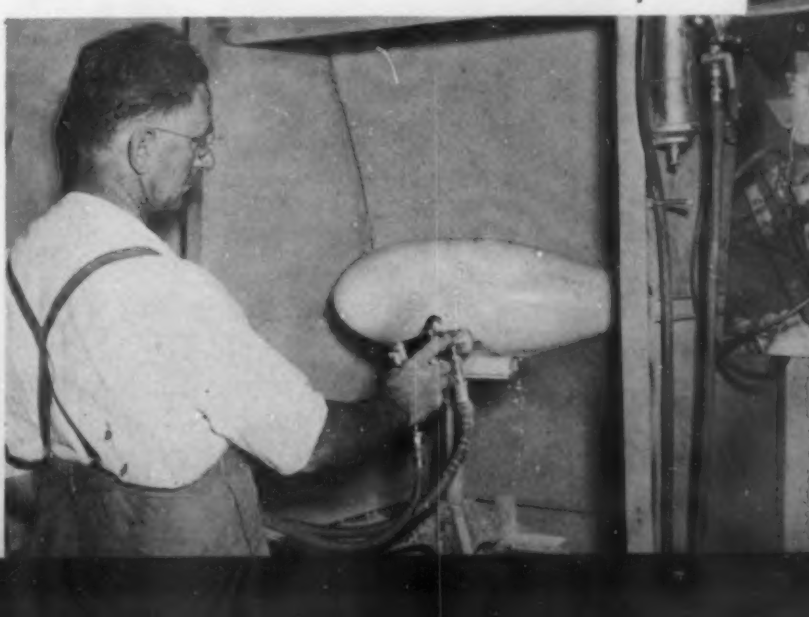


Rugged and resilient

by E. F. LOUGEE*

Tough, oil-proof plastic materials form sturdy, efficient tools used in aircraft manufacture, and protect fragile parts

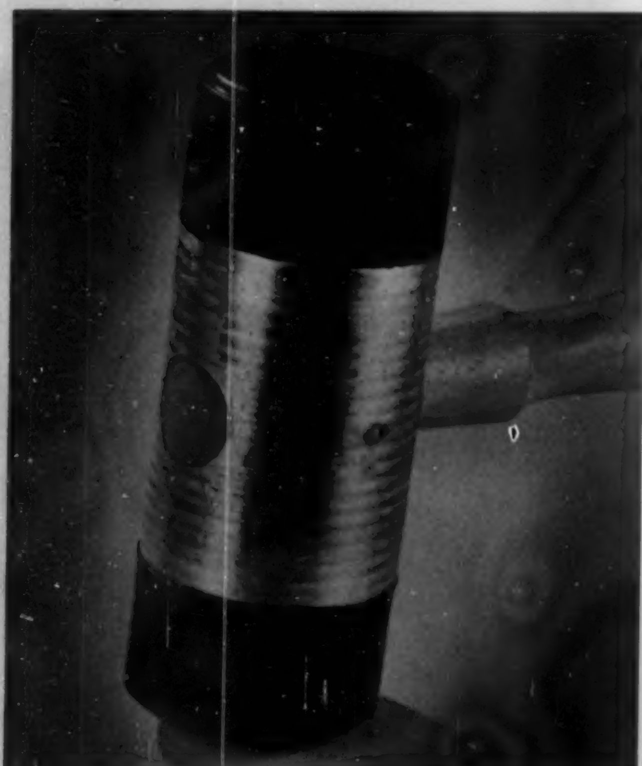
HERE is a hammer that really can take it. Thousands of them are doing their share for Uncle Sam—banging away in aircraft plants, machine shops and other factories where rapid blows shape aluminum, dural and other critical metal over forms, or where machine parts are assembled with hammer blows which neither scratch nor dent the materials used. This is important, especially in aircraft manufacture, where delicate tubing and other metal assemblies must be hammered into place without scoring or denting. Or where engine assemblies require sharp, forceful hammer blows which will leave no evidence that the part has been struck.

The head of this hammer is plastic, and its remarkable property lies in its toughness and ability to recover its shape within a comparatively short time, regardless of the abuse it receives. This means that should the hammer head become "mushroomed" from constant pounding, blow after blow on hard or soft metal, the tool doesn't have to be laid aside. Just flip the handle and use the other end of the head. In less than three minutes the mushroomed side has regained its original shape and can be used again. Thus, in working sheet stock, material won't pile up while another hammer is located.

If the hammer strikes a sharp edge of metal, it doesn't cut. It may look as if it were cut, and there may be a crease or recess in its surface an eighth of an inch deep or more.

* Plastics Institute.

1—***After three and a half months of constant pounding, this plastic hammer head shows little sign of abuse or wear***



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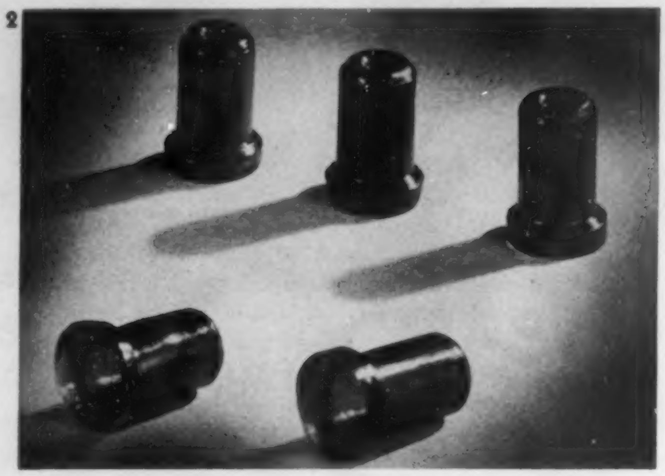


2—***Thimble-like molded plastic caps replace rubber as a protection for tubing and threads in aircraft construction***

This doesn't necessarily damage the plastic head, however, and within a few minutes the apparent "cut" will completely heal and disappear. The hammer pictured (Fig. 1) has been in use three and a half months, and was chosen instead of a new one to illustrate this point. A new handle has been put in because the old one was split from use.

The plastic head is claimed to be superior to rubber because it is not damaged by the grease and oil which are usually present in metal fabrication. It doesn't fray after a few weeks' use. It is said to retain its resilience even in cold weather, and to be resistant to most petroleum products, industrial acids and alkalies with which it may come in contact.

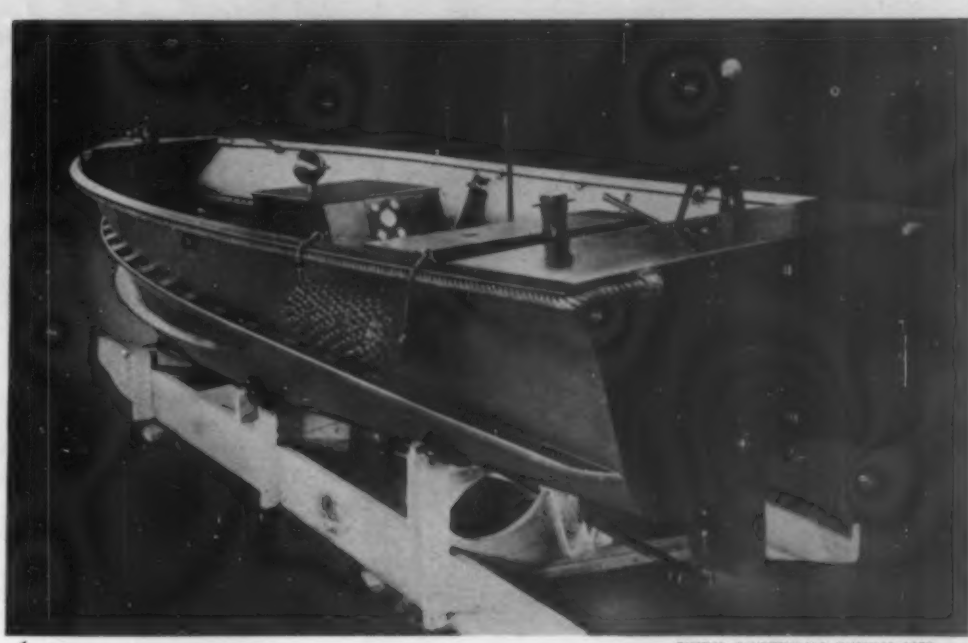
Made with face diameters from 1 to $1^7/_8$ in., the hammers are available in varying weights up to nearly 3 pounds. The light 1-in. and $1^3/_8$-in. sizes may be weighted if desired. Hammers are made also in two grades of hardness: the softer grade is for machine-shop use, while the harder type is especially suited to metal forming. No "sting" or vibration is experienced by workers in using these plastic hammers and therefore the fatigue factor is reduced to a very low point.

No plastic is indestructible, of course, and should the surface of the hammer head be badly damaged, a thin slice can be sawed off with a band saw and a smooth surface restored. With a face of as little as $^1/_2$ in. of plastic, the hammer will still have greater resilience than rubber, it is claimed.

Right now its greatest popularity is in the aircraft industry, but once the garage mechanic finds out about it, he will find plenty of places for using this plastic hammer because of its resistance to oil and gasoline and its other features. Straightening fenders and removing body dents are natural jobs for this flexible hammer to perform. It has sufficient weight to strike a substantial blow, yet the resilience of the hammer face will yield to curves and contours without leaving marks of its own.

The same plastic material used in the hammer is molded into thimble-like caps (Fig. 2) (*Please turn to page 116*)

1—*For an Army pontoon bridge, an equipment boat which is strong, light, hostile to marine growth and indifferent to the weather.* **2, 3**—*Molded in one piece, its tunnel stern hull (exterior at left, interior right) has faces of resin - impregnated birch, weighs only 245 pounds*



1

PHOTOS, COURTESY U.S. PLYWOOD CORP.

Boats for the Army

A "BRIDGE of ships" extends across the ocean, and is the peculiar province of the Navy and the Maritime Commission. A "bridge of boats," on the other hand, crosses a river or small sea arm, and is the responsibility of the Army, particularly the Engineer Corps. The floating supports of the latter—or pontoon—bridge must be light enough to be transported overland, sufficiently strong to carry mechanized equipment, and adapted to variations in climate.

Resin-bonded plywood, already at the wars in the form of airplane fuselages, patrol, landing and assault boats, barracks, skis, and other items of equipment, has been molded in one piece to form a tunnel stern hull for a pontoon bridge equipment boat. This molded hull (see Figs. 2 and 3) represents a plywood technique which distinguishes it from the resin-bonded plywood which has in the last few years gone to make not only combat boats but a variety of small pleasure craft. Its outer laminations are formed of "impregnated" plywood.

Fundamentally, here are the differences between the two types of material. Whether laminated in flat panels or molded into streamlined shapes, resin-bonded plywood is formed of layers of wood veneers. The innermost layer is the core, the two outside layers are the faces, and the two layers next to the faces (the wood grain of which runs at right angles to that of the faces) are the cross banding. If there are more than 5 plies, added layers between the core and the cross banding are the inner banding. With the exception of the faces, which are always left dry, alternate plies are coated on both sides with a phenolic or urea resin glue by passing them through a glue spreader, or by placing between them a dry glue film—a sheet of tissue paper impregnated with the resin. Thus, if there are 3 plies, the core is coated; if 5, the cross bandings; if more than 5, every other ply, beginning with the cross bandings. The faces (*Please turn to page 108*)

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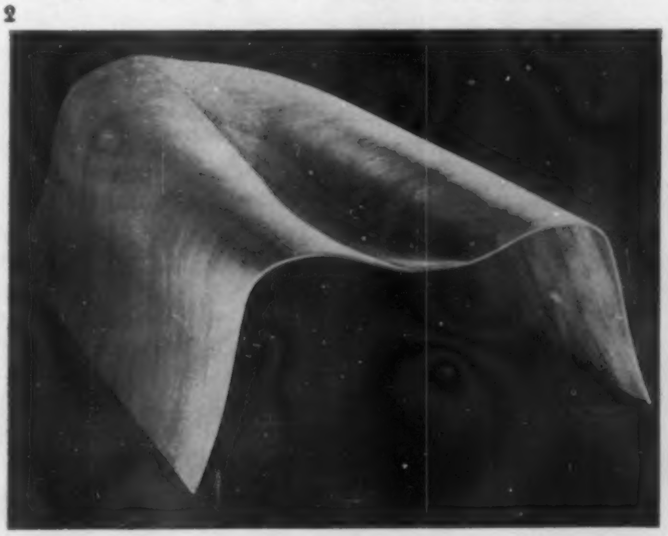

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Hand lantern

Needs of railroad men, linemen (for telephone and electrical companies), truck drivers, sportsmen, etc., were all considered when the Focal-lite hand lantern was designed. Molded of cellulose acetate butyrate, the assembly, consisting of 13 plastic parts, is lightweight (only about half that of aluminum), and is practically impervious to dents, cracks, or breakage as a result of rough handling. Color is permanent, and the material won't rust or corrode. The lantern (shown in transparent housing at right) has a $5^1/_2$-in. reflector and a 6-volt battery. It throws a half-mile beam which may be adjusted for flood- or spotlighting by simple thumb control.

The handle has been designed to fit naturally into a man's hand or to slip over wrist or forearm. It is assembled by screws and mounted on the battery box by threaded bushing and spherical nuts which are set in spherically recessed lugs molded on the box.

A special feature of this lantern is a "drop light" arrangement which makes possible the projection of light into inaccessible interiors such as the motor of a truck or the inside of a barrel or drum. The drop light is attached to a flexible cord, withdrawable from the handle, and can be pulled back into the housing by a crank-type reel.

Credits—Material: Tenite II. Molded by Modern Plastics Co. for Focal Co.

PRODUCT DEVELOPMENT

Minesweeper spars

Upon the doughty minesweeper and its courageous crew rests much of the responsibility for the safety of coastal shipping. Today, some of the U. S. Navy minesweepers and patrol boats which plow through our waters searching for lurking agents of destruction carry spars laminated from selected, sturdy spruce combined with urea-formaldehyde adhesive.

These hollow spars are built up to a square construction with pieces of spruce joined together with the resin glue in an arrangement of channeled or scarf joints. Each spar is skillfully turned by hand, and finished with expert care before it is finally put to the strategic use for which it is intended. The spars range from 14 to 70 ft. in length, and from 4 in. to a foot in diameter.

The urea-formaldehyde resin which goes into the construction of the spars is reported to have met all Bureau of Ships specifications. Aside from its quick-setting properties and the ease with which it can be applied, this urea resin requires no catalyst, a factor which greatly facilitates and simplifies the bonding operation. It dries to a rigid, shatterproof and lightweight surface, and has demonstrated its strength and dependability in use.

Credits—Material: Lauxite resin glue by I. F. Laucks, Inc. Spars manufactured by August Nelson.

Aircraft control pulleys

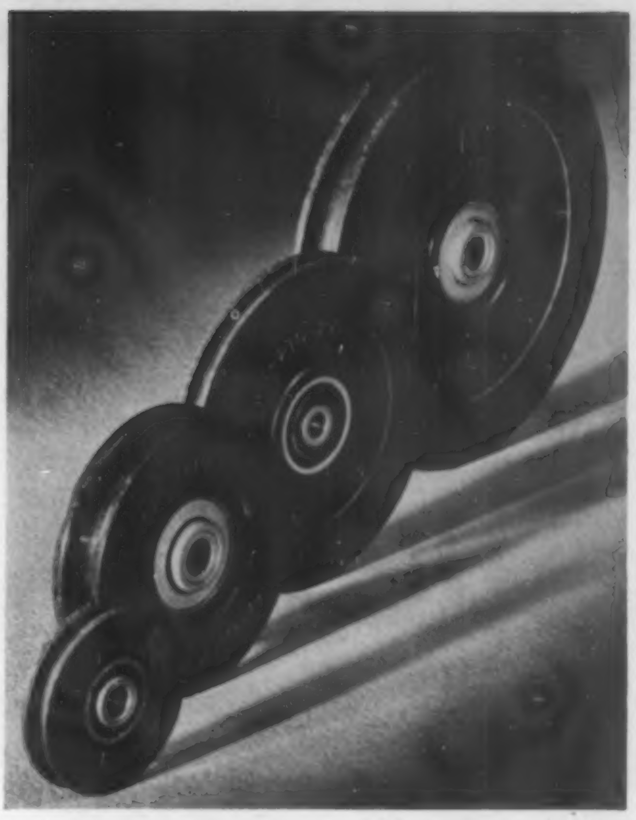
New, lightweight aircraft control pulleys of phenolic macerated fabric-filled compound have ball bearings integrally molded into each unit. Molded under heat and pressure by a special process, the pulleys are reported to have exceptional uniformity in the internal structure, and stability in external dimensions. The nature of the material and the molding process combine to make a smooth and hard finish in the groove, which increases the life of the cable and the efficiency of its operation. Molding the ball bearing into the unit as an insert not only saves weight by eliminating the need for a metal bushing, but also eliminates the potential variations in fitting the bearing to the bushing.

The molding process effects a perfect bond of the bearing circumference and the pulley, and also eliminates bearing distortion by maintaining the original concentricity of the bearing. This is achieved by exerting a uniform molding pressure against the bearing from all angles.

The plastic material is hard and unyielding, with a surface that has an excellent coefficient of friction—an essential quality since the pulley must be able to withstand the abrasive action of wire cable even when not precisely aligned.

The pulleys are available from stock in several sizes, as shown in the illustration at the right.

Credits—Material: Bakelite: Molder, Thomas Mason Co., Inc.



PRODUCT DEVELOPMENT

Grips for guns

Not lethal, but distinctly useful in the fight against the Axis is the gun for which this plastic grip was designed. It is used, not to spit death-dealing bullets on world battlefronts, but to fire signals for our armed forces, and as a tear-gas pistol by law enforcement officers and guards right on the home front.

Formerly manufactured from metal and hard rubber, the grip is now a solid, one-piece unit, transfer molded from a phenolic molding compound of unusually high impact strength. A four-cavity type mold is used, and the die has a sand-blast finish so that the completed plastic part has a dull, non-reflecting surface finish. The material is smooth and agreeable to the touch.

The conversion from hard rubber and metal to the high-impact molding plastic has not only resulted in a simplified and speedy production process, but is also reported to have increased the efficiency of the grip itself as well as that of the completely assembled gun. The plastic gun grip has been perfectly balanced without any sacrifice of strength or efficiency, and is described as being practically immune to all types of punishment such as rough handling, constant use and sharp variations in temperature.

Credits—Material: Bakelite. Molded by Jos. Stokes Rubber Co. for R. F. Sedgley, Inc.

Airplane pilot seats

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ASK a plane pilot what he deems essential requirements for a top-flight plane and for maximum flying efficiency, and the chances are that high on his list will be "a comfortable place to sit." With increasing speed and longer flights, the importance of controlling and diminishing pilots' fatigue is a major consideration for the plane designer; and comfortable, well-constructed, lightweight seating facilities for the plane pilot contribute in a large measure to the realization of this end. Builders of airplane seats are confronted with the problem of fitting a complex human being into an inflexible mechanism, and the satisfactory solution of the problem means that provision must be made for the diversified aspects of the human form, the cumulative fatigue resulting from a sustained sitting position, particularly with the added strain to which today's pilots are subject, and the important limitations of space and weight.

In the past, because of the difficulties encountered with inferior animal and vegetable glues as applied to wood structures, plane seats were made chiefly of metal. Animal and vegetable glues had little or no resistance to water or to fungus growths, and structures bonded in this fashion were obviously neither safe nor economical because of their limited and uncertain span of usefulness. The development of synthetic resin adhesives which offered excellent bonding characteristics and complete immunity to moisture and mold growth, opened up a new and successful field for the use of plastic plywood and plastic impregnated fabric laminates in the construction of aircraft parts. The pilot's seat is one of the latest plane components to be converted to such plastic construction. This conversion resulted from a recent

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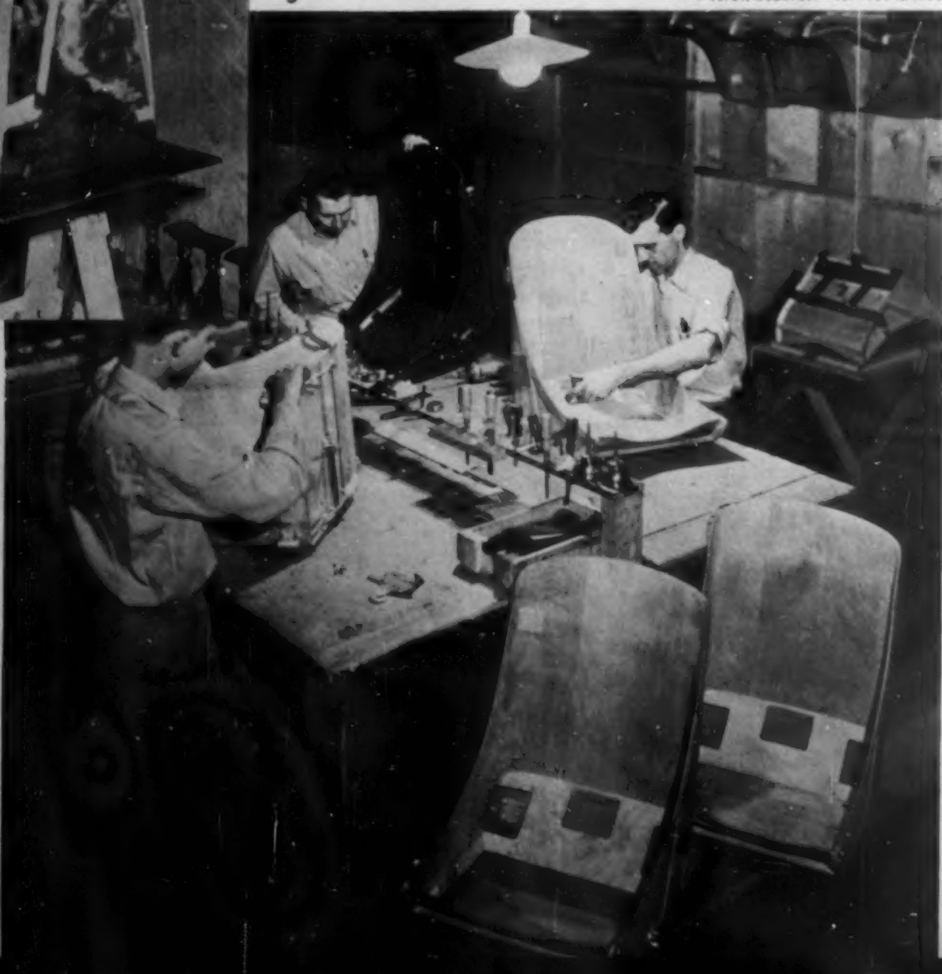
PHOTOS, COURTESY [illegible] AIRCRAFT



1—In one process of pilot seat manufacture, strips of hard birch veneer are bonded together before molding on this tapeless splicer. 2—Back and sides of seat, formed over a single solid mold, are inserted into a rubber bag to ensure even pressure during setting of plastic resin glue. 3—Seats inspected after assembly (foreground). Note glue blocks and stiffeners in bottom section of seat

Government directive to all manufacturers of training planes to substitute laminated plastic and plastic plywood seats in the place of metal as rapidly as possible. The seat to be constructed had to meet specified service requirements before approval was granted, and had to be subjected to and pass definite static load tests as outlined by the Services. For example, Specification AN-RR-S-176 required:

A load of 2400 lb. to be applied to the seat bottom.

A down load of 1200 lb. to be applied to the back of the seat (with back of seat horizontal facing upward).

An up load of 1600 lb. to be applied to the safety belt attachments of the seat (load applied in a direction inclined at a 40° angle from bottom of seat).

An up load of 1500 lb. to be applied to the safety attachments of the seat (applied in a direction inclined at 101° from the seat bottom, parallel to the seat back).

A load of 1400 lb. ultimate in a forward direction parallel to the seat, and a load of 1200 lb. ultimate, in an upward direction perpendicular to the bottom of the seat, applied simultaneously to the chest-type harness attachment fittings.

Several manufacturers of plane parts have succeeded in developing constructions that meet such specification requirements, and pilot seats of plywood and synthetic materials are now integral parts of a number of planes already in use. One manufacturer uses strips of birch veneer joined on a tapeless splicer (see Figs. 1–3) in order to achieve positive bonding by this automatic gluing process. All veneer used in the manufacture of pilot seats by this company is first fabricated into sheet stock and minutely inspected to make certain that it conforms to fixed specifications. The back and sides of the seat are formed over a mold in a single unit. Plies of Michigan hard birch veneer are shaped to the actual contours of the seat before the assembly is set into the autoclave. The rubber bag molding process is used to assure even and consistent pressure while the urea-formaldehyde resin bond sets. Two seat backs can be formed on a single mandrel.

The completed wood shell consists of two major units—the back-sides structure formed in one piece, and the bottom section formed separately. A tension strap carries completely around the seat as a bead for added stiffness and rigidity of this structure. Glue blocks and stiffeners constructed of vertical grain spruce are placed on the bottom of the seat (Fig. 3) and are used inside and outside the unit to bind the back and sides to the bottom section. The entire wood structure is bonded with a urea-formaldehyde glue that is described as being fully waterproof and capable of withstanding heat up to 170° F. Fitted for the B11 type Army safety belt alone, the seat weighs 7 lb. 2 oz., and with shoulder harness take-up mechanism, 9 lb.

This seat has been subjected to all loads in excess of required specifications and it is reported that no permanent deflection resulted, nor was there any failure of any part. Vibration tests imposed also demonstrated the practicability of this plastic-bonded plywood seat construction.

Another manufacturer has just completed a plywood seat, and is now awaiting Government approval before proceeding with production. This seat (Fig. 6, page 118) has also been designed to be molded by means of heat and fluid pressure. A special modification of the rubber bag molding process is employed. The form is made in such a manner that the seat is taken off the mold practically ready for fittings.

One of the chief difficulties encountered in this fabrication was to obtain a good corner. Usually, seats made of wood have a tendency to separate at the corners, and in order to avoid such a contingency this manufacturer molded in pieces of laminated plastic material thin enough to bend around the corners. Three laminations of plasticized veneer are wrapped around a solid wood mold which is an exact reproduction of the finished seat. Before insertion into the autoclave, the fabrication is put into a membrane bag which causes even pressure to be exerted on the form during the molding process. The fabricated shell is removed from the wood mold after heat and fluid pressure have been applied.

The original design, although only slightly over the weight of the metal seat, proved to be (*Please turn to page 118*)

PHOTOS, COURTESY CAPAC MANUFACTURING CO.

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4, 5—Back and front view of another aircraft pilot seat, with fittings attached. Here a canvas fabric especially woven for high tensile strength is impregnated with a modified phenolic laminating varnish, and material is laminated into a single rigid piece

5

Soft, rubber-like plastics

by D. R. WIGGAM*

Cellulose derivatives compounded with chemical and oil plasticizers yield new plastic compounds to replace rubber in many applications

THE production of rigid plastics from cellulose derivatives, such as cellulose acetate, cellulose nitrate and ethyl cellulose, is a well-established art. Products made from this general type of plastic may be illustrated by fountain pen barrels, toothbrush handles and many other articles. These same cellulose derivatives have properties which also make them suitable for use in the production of less rigid plastics. The wider range of usefulness of soft plastics has been largely overlooked except in a few instances, such as the use of cellulose nitrate in artificial leather. This possibility of using cellulose derivatives in soft rubber-like plastics has particular significance today because of the growing scarcity of natural rubber.

Composition and formulation

Cellulose derivatives, such as ethyl cellulose, may be compounded with chemical and oil plasticizers to yield compositions having many of the qualities which have made rubber applicable in a wide variety of uses. These compositions can be made to be tough, pliable, flexible and thermoplastic. Their handling is different from that of rubber. Vulcanization is unnecessary. This usually results in faster processing and higher production rates. On the other hand, the advantage of converting the materials to less soluble forms by means of vulcanization is not possible with the soft plastics. In most cases, however, solubility characteristics can be controlled by proper choice of the cellulose derivative and its modifying agents. Possible formulations are almost limitless, since each plasticizer gives somewhat different characteristics. Furthermore, formulations may be modified still further by addition of waxes, resins or pigments.

Properties

Some of these soft-plasticized cellulose formulations have been tested in the laboratory in comparison with two types of widely used rubber compositions. Table I contains the results obtained on testing three of the ethyl cellulose and two of the cellulose acetate unpigmented formulations, along with comparable data for the two rubbers. One of these rubbers was an unpigmented stock, such as is commonly used in rubber gloves and baby pants; the other rubber stock was a black pigmented one similar to that used in inner tubes for automobile tires.

The cellulose derivatives can be formulated to yield products having some qualities equal to or even superior to those of rubber compositions. For example, formulations have been made with abrasion resistance several times greater than that of the two rubber samples tested. Their degree of elongation is limited, however, when compared to rubber; and on the same basis of comparison, their "bounce" is low. They can be formulated to show only minor permanent deformation when subjected to stress at room temperature.

Water resistance comparable to that of compounded rubbers can be built into these soft plastics. They can be made to show good pliability at low temperatures. For example, at a temperature where the rubbers were stiff, boardy and brittle, the soft plastics were still pliable and tough. Good chemical resistance is readily obtained. To illustrate, the two rubbers used for comparison purposes became brittle after only 7 minutes' exposure in a stream of air containing 3 percent ozone. Some of the cellulose plastics were not brittle and appeared unaffected after 96 hours' exposure to the same concentration of oxone. They also showed good resistance to dilute alkalies.

Other desirable properties may be built into these soft plastics by proper choice of modifying agents. They can be made oilproof or gasolineproof. Flameproofness may be added by use of proper plasticizer. They can be formulated to be clear or pigmented, to cover the entire range of transparent, translucent or opaque colors.

Fabrication

Both cellulose acetate and ethyl cellulose compositions are readily fabricated by injection or extrusion molding or by hot calendering. They can be applied also in solution or in a solvent-jelled state as is done with cellulose nitrate in artificial leather.

Solvents and plasticizers

The data in Table I are presented to illustrate the characteristics which the soft rubber-like plastics possess. These formulations were made from ethyl cellulose and cellulose acetate, all without the use of any solvent. Formulations from cellulose nitrate, however, would require solvent and a curing step in the production cycle because this cellulose derivative must be worked at lower temperatures due to its lower stability at elevated temperatures.

It has been pointed out that both hard and soft plastics may be made by proper choice of plasticizer. Cottonseed oil or raw castor oil are examples of oil plasticizers which may be used with ethyl cellulose. Dibutyl phthalate and Hercolyn[1] are examples of chemical plasticizers. Dimethyl and diethyl phthalates and Santicizer M-17 (methyl phthalyl ethyl glycolate) are examples of satisfactory plasticizers for use with cellulose acetate.

It is believed these soft plastics which can be made from ethyl cellulose, cellulose acetate and cellulose nitrate can be used to advantage today in supplying essential needs of both the armed forces and civilians.

[1] Reg. U. S. Pat. Off. by Hercules Powder Co.
NOTE: (See table on opposite page).
[1] Quick tension test. To standard size samples, a 20 percent stretch was applied for a 2-min. period with stretch maintained for a total of 10 minutes. Then sample was allowed to recover for 24 hr. after which the percentage retained of the stretch given was recorded.
[2] Slow tension test. To similar samples (30 mils) a 200-gm. weight was applied and left on for 24 hr. or until a 20 percent stretch was reached. (In some cases samples never attained the 20 percent stretch.) Then at the end of 24 hr. recovery, the amount of stretch was measured as above.

* Hercules Powder Co.

Table I.—Properties of Typical Soft Plastics

	Ethyl cellulose[A]			*Cellulose acetate*[B]		*Rubber*[C]	
	I	II	III	IV	V	VI	VII
1. **Water Absorption:**							
Percent of original weight after 24 hours	105.1	104.9	104.2	97.4	90.9	112.8	100.9
Percent of original weight after 48 hours	105.3	111.5	104.9	94.9	86.8	115.3	101.1
Percent of original weight after 70 hours	106.0	112.8	106.3	92.8	84.2	117.6	101.2
2. **Dimensional Stability in Boiling Water:**							
Percent of original length after 10 minutes	98.0	99.5	....	w	w	102.0	100.0
Percent of original width after 10 minutes	101.0	101.0	....	w	w	103.9	100.0
Percent of original thickness after 10 minutes	104.0	103.6	....	w	w	100.0	100.0
Appearance after removal from water	c	vh	....	o	o	Opaque initially	Opaque initially
3. **Dimensional Stability in Water at Room Temperature:**							
Percent of original length after one week	102.4	107.6	....	94.5	95.0	110.0	101.0
Percent of original width after one week	103.0	107.5	....	96.2	93.2	109.2	100.0
Percent of original thickness after one week	106.2	107.3	....	96.7	90.0	112.5	101.5
4. **Elemendorf Tear Test:**							
Force-grams to tear 1.25 inches	68	19	41	29	29	Not run	Not run
5. **Abrasion Resistance:**							
Revolutions/mil thickness	23.4	3.7	75.5	117	94	37	49
6. **Pfund Hardness:**	.367	.712	....	.775	.285	.8+	.8+
7. **Penetration Melting Point:**							
Degrees centigrade	66	No sol.	....	123	30	102	Sample too thick
8. **Shore Hardness:**							
Shore values	31	29	27	32	34	Sample too thin	90
9. **Tensile Strength:**							
Pounds per cross sectional square inch	1700	1170	2290	3400	2300	140	470
10. **Percent Elongation:**	103	86	123	109	115	760	575
11. **Permanent Set:**							
Percent of total stretch retained from quick[1] tension, 21° C. (Scott tester Dh-2)	9	6	24.2	45	75	0	0
Percent total stretch retained from slow[2] tension, 21° C.	11.5	81	....	100	100	0	0
Percent total stretch retained from slow[3] tension, 50° C.	100	100	....	90	83	0	0
12. **Flexibility at −20° C.:**							
Number double folds (M.I.T. Flex Tester)	170	No sample	97	40	38	65,000+	Sample too thick
13. **Flexibility at Approximately −78° C.:**							
(Pinch test)	b	f	b	b	b	f	b
14. **Burning Rate:**							
Seconds for 3-in. length	71	28	....	33	44	20	66

b = brittle
c = clear
f = flexible
o = opaque
vh = very hazy
w = wrinkled

Identification of materials tested:

A—Ethyl cellulose, Grade "N" used (46.8 to 48.5 ethyl content, 100 centerpoise viscosity)

Composition, Col. I: Ethylcellulose; Raw castor oil

Col. II: Ethylcellulose; Cottonseed oil; Raw castor oil

Col. III: Ethylcellulose; Raw castor oil; Opalwax

B—Cellulose acetate, Grade PM3 (52–54 percent esterification)

Composition, Col. IV: Cellulose acetate; Santicizer M-17

Col. V: Cellulose acetate; Dimethyl phthalate; Diethyl phthalate

C—Rubber

Composition, Col. VI: Unpigmented, light (such as used for rubber gloves)

Composition, Col. VII: Black pigmented (such as is used for inner tubes)

[1-3] See note on opposite page.

Planning postwar applications

by CARL SUNDBERG and MONTGOMERY FERAR*

THE preparation for the peace which will inevitably follow the war is as vital to the nation's existence as has been the preparation for the war itself. Only through foresight and definite planning for the future will many products and producers survive. Of course, at present nothing can be allowed to interfere with the war effort. Yet post-war planning and designing must inevitably be started long before that happy day when the last shot has been fired. While at present all the engineering brains of the country are concentrated on the tremendous task of swinging into war production, the time may come when total production is a reality, and at least skeleton crews of engineers will be available to work with the industrial designers on peacetime planning.

The development of new products will logically follow the tremendous technical strides made in many fields due to the catalyzing effect of the war. Plastics will emerge as a leader in this advance. With the capacity of the industry steadily increasing, volume production of many new items is in sight. These new plastic applications will be practically limitless.

Plastics can be used to a much greater extent in household refrigeration and may, in fact, revolutionize our present conception of the refrigerator. There is no reason why a refrigerator should be made of metal and cling to the old-fashioned ice-box type of construction. Entirely new construction methods could be utilized—which does not necessarily mean the development of new techniques but simply the extension of techniques already in practice to the refrigeration field. The following suggestions must be taken merely as starting points for research and development work.

1. There is the possibility of getting away from orthodox refrigeration construction. An integral housing can conceivably be molded of a resinous-pulp-fiber composition. Molded under pressures as low as 50 lb. per sq. in., a porous type of material may be produced which should have relatively low thermal conductivity. A tier arrangement of molds is possible to speed up production. High-frequency current offers another possible source of a rapid molding cycle. By use of a thin surface sheet of a much higher resin content, perfectly smooth exterior surfaces could be achieved covering the porous core. With this technique, which is similar to that used on the experimental Ford plastic car, the entire refrigerator housing could be preformed by the vacuum method and molded in one integral piece. Even the shelf brackets and evaporator mounting could be molded onto the inside, saving much assembly. The same technique would be applied to the door, and the horizontal reinforcing webs could be utilized as shelves for vegetables.

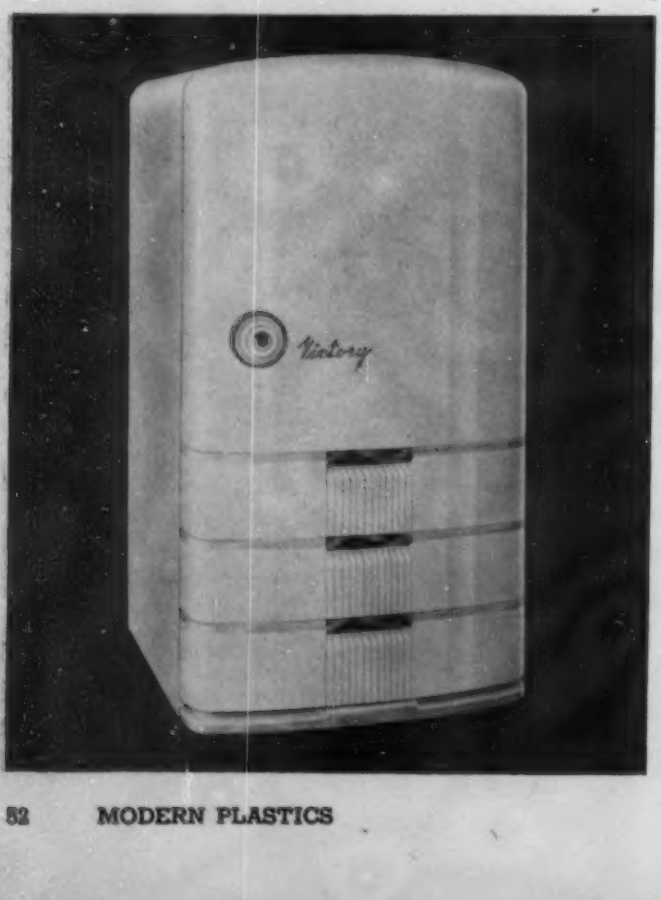
2. A modification of this idea might be experimented with at first. The inner liner of the box might be molded with integral shelf brackets by the "battery box" technique, using some sort of asphaltum compound.

3. The liner could be molded of plastic-impregnated fibers with horizontal reinforcing webs used as shelves.

* Industrial designers.

1,2—As different from today's household refrigerator as the latter is from the old springhouse of Civil War days, this hypothetical refrigerating unit contemplates an entire housing molded in one integral piece. Transparent plastic drawers, molded in one shot, serve as hydrator and food bins

1



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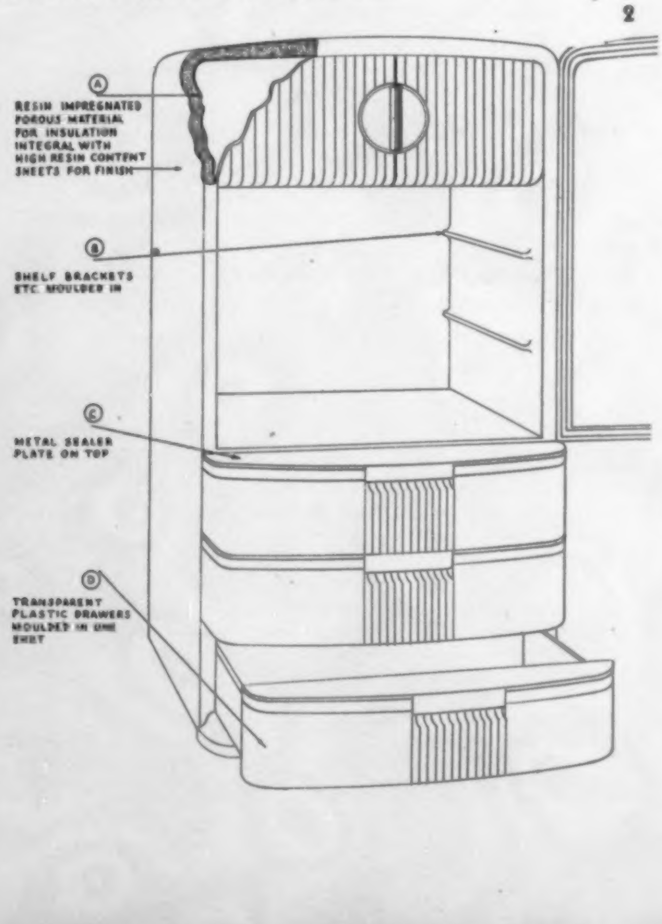

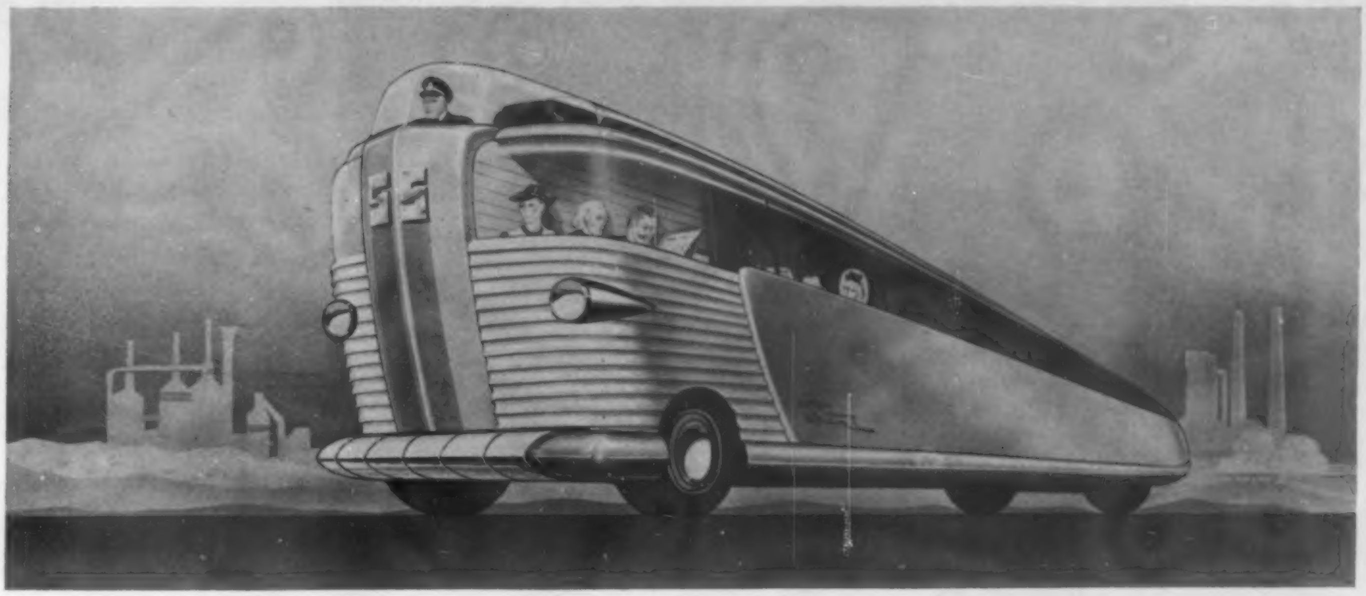

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3—Like a pilot in his plastic turret sits the driver of the bus of tomorrow, with nothing to obstruct his view. Passengers, too, get their money's worth of scenery, are protected from glare by translucent plastics on the interior. 4—Fastening transparent plastic legs to one-piece, molded body is the only assembly operation necessary in the construction of a plastic postwar chair, upholstered with woven extruded plastic

4

4. There is also the possibility of constructing the inner and outer shells of plastic with dead air cells in between.

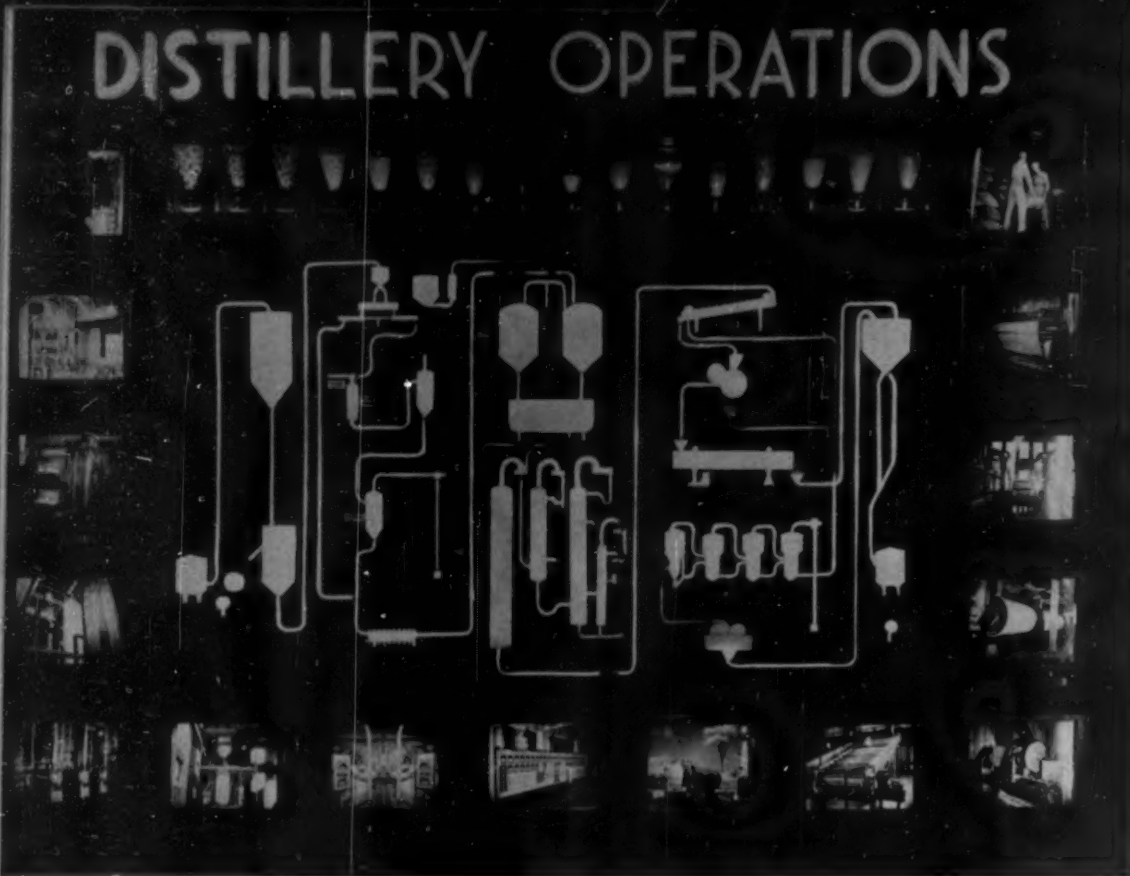
5. A new functional conception of a refrigerator is possible. For instance, it could be designed as a chest of drawers, each drawer having its own seal and locking device. Only one drawer need be opened at a time causing less confusion and providing greater accessibility, less heat loss and dehydration of stored foods. Production of these drawers could be a very practical molding job. A double-walled front would be provided with insulation space which could be sealed by a stamped metal cap. The double panels would be made of a transparent material allowing one to see the interior only when the light was turned on. On either side of the transparent panel the front can be painted inside to add to the beauty of the design. With the larger plastic presses about to be built, this drawer could be molded in one shot. The whole cabinet could be manufactured with a minimum of assembly. The material to be used is not affected by fruit acid and will not frost up.

6. This drawer principle could be applied to the lower half of a conventional refrigerator providing a hydrator drawer and two food bins (see Figs. 1, 2).

7. A refrigerator could be constructed of resin-impregnated plywood. Several companies have been working on a "sandwich board" consisting of two layers of plywood with insulation material between, all pressed into one piece; this construction is now being used in prefabricated houses, and the same principle could be applied to refrigerators.

8. The provision of a separate plastic door for the freezing compartment, allowing access from the exterior, would permit the removal of ice cubes or frozen foods without warming up the food compartment.

Much publicity has been given recently to the use of plastics in automobiles. Proponents cite the many possibilities: one-piece, transparent, streamlined windshield and tops, which would allow greater visibility and consequent safety and, at the same time, freedom from dust and wind; dent-proof fenders; lighter weight bodies; and beautiful iridescent and variegated colors which go all the way through. However, there are many serious objections to the incorporation of transparent plastics in passenger car design at the present stage of the plastics industry. Plastic tops create terrific heat problems and require powerful air conditioning. Some means of shading against excessive sunlight must be provided to protect occupants from the burn resulting from ultraviolet ray penetration of the material. Transparent materials need constant maintenance to keep their relatively soft surfaces free from scratches and gravel dents. Care must be taken in the design to provide flat areas of plastic over which windshield wipers can operate, as no one yet has invented one that could wipe a surface curved in two directions. In fact, this wiper problem is a critical one from more than one angle, for until the *(Please turn to page 116)*



Here the entire model is illuminated following the full 7-minute cycle showing the complete process. In the course of the demonstration, only one section at a time is illuminated, as each phase of the process unfolds. Samples of materials used are contained in the small flasks across the top of the model

Industrial process in miniature

"LEARN by doing" is an old and tried educational precept which has demonstrated its truth through the years. When active and actual participation is not practicable, however, perhaps the next best way to learn is by observation—by watching something being done. Small-scale demonstration models are not new. They have been successfully and effectively employed in scientific laboratories, industrial workshops, museums and construction projects for many years. One of the most interesting and unusual developments along these lines is the recent construction of a small animated, industrial demonstration model, constructed entirely of plastic materials, which makes full use of the unique light-catching qualities of certain types of plastics.

This exhibition model portrays the various processes involved in the manufacture of industrial alcohol from grain, and the conversion of de-alcoholized mash from a useless waste product to an important animal feed. It depicts the progress of chemical engineering which has made possible the conversion of an obsolete batch industry to a modern continuous one.

A test display measuring 4 ft. long, 3 ft. high and 10 in. thick, the model has a background panel of black laminated phenolic against which is set a third-dimensional relief of frosted methyl methacrylate letters and diagramed operating units or "flow chart." The control operating unit is geared to a system of progressive lighting arranged to illuminate one section of the flow chart at a time for a 1/2-min. period. Thus the student or observer may concentrate his attention on a single operation and on one mechanism in the order of development of the process without being diverted by succeeding operations. Whenever a chemical or physical change occurs in the process it is indicated by a change of color. Every variation in composition of the product is indicated by a corresponding increase or decrease in the intensity of the color.

Bordered along the sides and (*Please turn to page 120*)

PHOTOS, COURTESY HOUSE OF PLASTICS

Precision tools and craftsmen's skill are used to assemble this miniature industrial model. The background panel of laminated phenolic has been diagramed preparatory to applying the methyl methacrylate units which comprise the flow chart and the title at the top

Extruded tubing in war production

by J. E. PIERCE*

THERMOPLASTIC tubing made by the continuous extrusion process is steadily gaining in acceptance with manufacturers of war and essential civilian goods. Because of the wide range in properties of the various thermoplastics, replacements can be made for tubing now formed from metals, rubber and other critical materials. In numerous instances, the substitute is proving to have advantages over the material replaced.

Tubing of uniform dimensions is manufactured in outside diameters from .050 in. to about 1.5 in., with work continuing to extend the size range. As extruders add larger equipment and work out processing improvements, it is expected that this size range will steadily increase. Stock of a few sizes is carried at various points, but generally such tubing is made to special order because of the thousands of possible combinations of size, wall thickness, plastic formulation and color.

Wall thickness can be supplied from .010 in. to .5 in., depending on the outside diameter of the tubing required. Special slow cooling methods are required to eliminate void bubbles in thick-walled tubing. At present, average tolerances are plus or minus 1 percent of the outside diameter, with somewhat closer tolerances possible by special methods and by rejection in inspection operations. These tolerances are close to the optimum, since dimensional changes of the same order of magnitude are caused by temperature and humidity variations. Possible tolerances also depend on the uniformity of the material furnished the extrusion processor. A completely

*Pierce Plastics, Inc.

SPECIFIC USES OF THERMOPLASTIC TUBING

AIRCRAFT—military

The requirements here for service at from −70 deg. F. to +170 deg. F. severely limit the number of applications for thermoplastics. There are no thermoplastics suitable for stress- or impact-resistant parts which must maintain dimensions through this temperature range. However, certain uses with proper design do not demand complete dimensional stability and for these thermoplastic tubing is suitable. Some of these are as follows:

- Flexible, electrical insulating sleeving for ignition, instruments and radios
- Lines for air or vacuum connections where proper support is given, and differences between pressure inside the tube and the atmosphere are maintained at a low value
- Gage glasses
- Covering shields for instruments, indicators, lights, gages
- Rigid sleeving, for conduit for wiring, and for terminal insulators
- Directional flow indicator clip rings
- Flexible coverings for support hangars and fastening clips
- Antennae bushings and feed through insulators
- Oxygen tubing
- Pilot's relief tubing
- Rip cord housing

AIRCRAFT—civilian and training

There is an increased latitude in usages for civilian aircraft because the required temperature range is not so wide, and planes may be designed with somewhat less rigid requirements generally. The applications mentioned above can be made with less special attention to protecting against impact or deformation, and higher stresses may be used. Also the following additional applications should be considered:

- Lubricating oil lines
- Cooling water lines
- Gasoline lines
- Directional channel for radio or choke control wires

The saving in weight over metals is a factor worth considering in all aircraft applications.

TRANSPORTATION EQUIPMENT

Actually, for ships, tanks, trucks or buses, so different in purpose and appearance, thermoplastic tubing applications are very similar to those in aircraft. The functions of conductance of fluids and of electricity are the same in engines, instruments, radios and control systems regardless of the particular assembly into which the parts fit.

TRANSPORTATION EQUIPMENT (*con't.*)

On ships, gage glasses for low temperature, low pressure water tanks are an additional possibility, as are speaking tubes. Ships also carry kitchens, plumbing, refrigeration, laboratories and air conditioning plants where further uses develop.

Trucks may further apply thermoplastic tubing to

- Windshield wiper hoses
- Radiator overflow tubes

HOUSING

- Gas lines for stoves and refrigerators (use metal in high temperature zones)
- Refrigerant lines
- Water lines and small drain lines
- Humidifier piping
- Oil burner and gas furnace lines (restricted as for stoves above)
- Conduit for electrical wiring
- Stand pipe tubes in toilet flush tanks

MEDICAL AND LABORATORY USES

- Flexible laboratory tubing
- Rigid laboratory tubing
- Catheters
- Terminal insulators for leads
- Handle covering for tools and instruments
- Piping

Tubing can be readily formed and cemented for tees, ells, siphon tubes, manometers, etc., to replace fragile glass. It is not as universal in its resistance to solvents, however, and can be used only at medium temperatures.

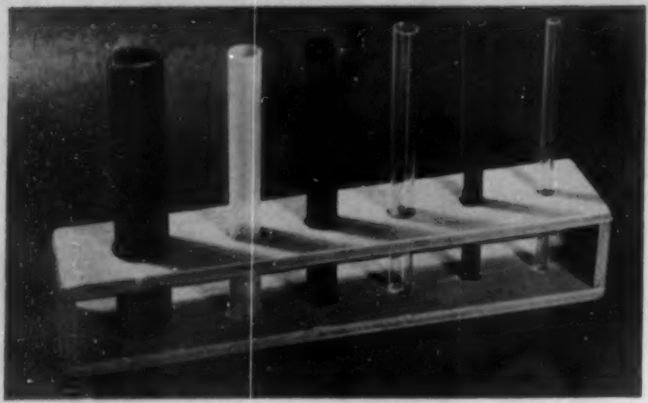
MISCELLANEOUS USES

- Fire extinguishers
- Paint sprayers
- Coolant and lubrication lines for machine tools
- Air compressor lines

Machined and formed tubing is being used in increasing extent for many types of small parts, as for:

- Washers
- Bushings
- Gaskets
- Spacers, etc.

These are generally peculiar to specific designs of products and are not of general interest.



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PHOTO, COURTESY PIERCE PLASTICS

1—Samples of thermoplastic tubing of opaque and transparent materials in varying diameters made by continuous dry extrusion

homogenous plastic can be melted and made to flow uniformly, thus making possible an exactly even passage of the plastic through the tubing die. Here again improvement is steadily being made.

Table I lists briefly the outstanding properties of the most important thermoplastics. Some materials still in development, or otherwise not generally available, are not considered, properties and limitations of those listed are being improved.

TABLE I.—PROPERTIES OF THERMOPLASTICS USED FOR TUBING

Material	*Outstanding properties*	*Use limitations*
Cellulose acetate and acetate butyrate	Ease of fabrication Uniformity Dielectric strength	Extremes of temperature Solubility Moisture absorption
Ethyl cellulose	Ease of fabrication Uniformity Dielectric strength Resistance to impact at low temperature	High temperatures Solubility Moisture absorption
Acrylates	Clarity Dimensional stability Weather resistance Rigidity Dielectric strength Uniformity Ease of fabrication	Non-flexibility
Polyvinyl alcohol	Elasticity Solvent resistance	Water solubility
Polystyrene	Superior dielectric strength Low power factor Dimensional stability	Brittleness
Polyvinyl chloride-acetate	Elasticity as desired Chemical resistance Dielectric strength Water resistance Dimensional stability	Low softening point
Polyvinylidene chloride	Superior chemical resistance High softening point Dielectric strength Flexibility Lack of cold flow	Brittleness at low temperature

A few comments on Table I may be in order. Cellulose acetate materials are the oldest of the group and for years have had hundreds of uses. These plastics form the backbone of the injection-molding and extrusion processing industries. Ethyl cellulose is very similar in properties to the cellulose acetates, but is not in large production. A new formulation just developed has outstanding resistance to impact at low temperature, and approaches the thermosetting plastics on this score.

Acrylates have had a wide acceptance in the decorative and utilitarian fields where clarity is required. Weather-resistance also adapts them to uses under conditions of outdoor exposure. Uses for polystyrene have developed rapidly because of its moisture resistance and exceptional electrical properties. Polyvinyl alcohol is used for flexible tubing where resistance to certain solvents and oils is required. Vinyl copolymer plastics are being substituted for rubber in many applications where extreme resistance to high temperatures is not required. Their electrical properties have led to large-scale uses in the insulation field.

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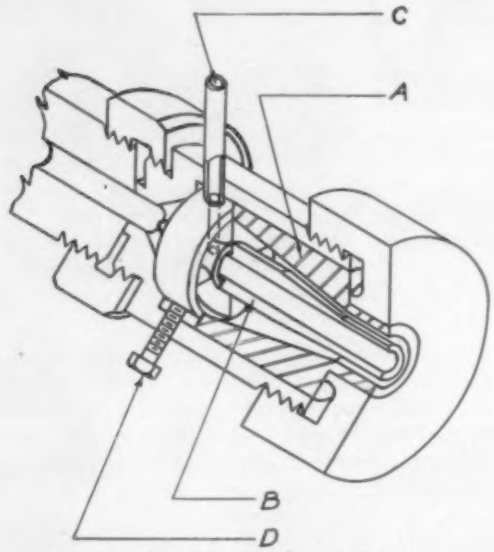

2—One method of feeding air under pressure through the mandrel to keep the tubing round while it cools: A, tubing die; B, tubing mandrel; C, air inlet; D, adjusting screw

Polyvinylidene chloride is available in only one formulation, but is being accepted to replace copper tubing in many instances. The allowable working pressures, the ability to withstand high temperatures for short periods and the low cost are all noteworthy. Tubing is made in unoriented crystal structure only, so does not exhibit the high tensile strength of the oriented form. Tolerances on dimensions of the extruded tubing cannot be held as closely as for other materials, apparently due to lack of uniformity in the raw material.

Extrusion process

The dry extrusion process for manufacture of tubing uses the same screw type machine as is used for rod, sheet, special shapes or wire insulation. The machine consists of a rotating screw in a barrel. The barrel is heated by any method giving close control over a gradient of increasing temperature from the feed end to the discharge end.

Either a right angle or a straight through die-holder is fastened at the end of the barrel. This must be heated and the temperature accurately *(Please turn to page 130)*

Parachute flare base

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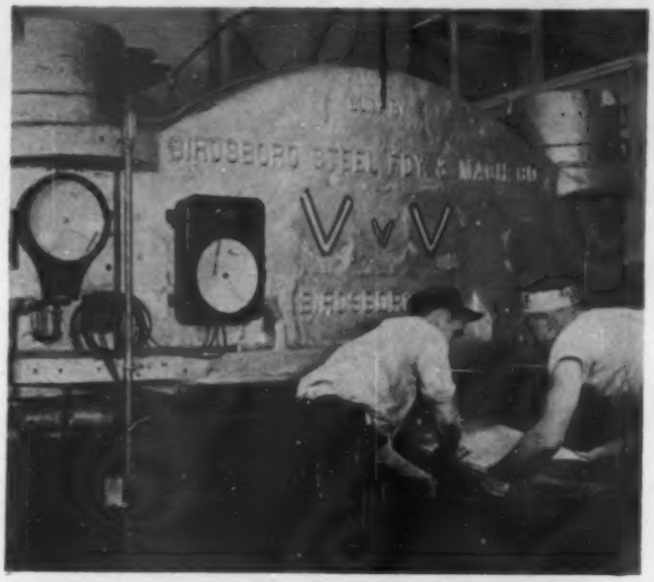

2


PHOTOS, COURTESY ARMSTRONG CORK CO.

IN war and in peace, for commercial as well as for military flying, parachute flares are indispensable accessories in an airplane. Somewhere over enemy territory an American bombardier will press a button in his ship, releasing a switch which will cause a parachute flare to plummet to earth from the wing or fuselage of the plane, blazing a 75,000 candle-power path to the target for which his bombs are intended. The unknown hazards of a forced landing may be lessened by the use of a flare to light up unfamiliar terrain in an emergency. The magnesium flare may be used as an improvised but effective "flash bulb" for night photography or, again, it may serve as a distress or call signal to distant planes by planes forced down unexpectedly.

The parachute flare base block which functions as the container for the flare mechanism has in the past been constructed of aluminum which, lightweight, hard and proof against moisture, possessed all of the qualities essential to equipment of this type. In an effort to alleviate the present aluminum shortage, one company has been experimenting with different types of material for the flare base, and has just succeeded in perfecting a laminated plywood parachute flare base, which not only has proved itself in use, and demonstrated its suitability for the functions required of it, but has resulted in a unit that is somewhat more economical than its predecessor.

In developing this part, the manufacturer began with approximately 40 laminations of $^1/_{32}$-in. wood veneer arranged so that the direction of the grain alternated in adjacent plies. This thickness proved inadequate for the strength required, and the final dimensions fixed upon provided for a veneer $^1/_{32}$ in. thick arranged in alternate long and cross grain layers with a resinous type of dry film glue between the plies, which vary in number from a minimum of 53 to a maximum of 59 per board thickness depending upon the type of wood selected.

The flare base blocks are molded in flat sheets and machined to shape, thus reducing tooling costs to a minimum. A minimum of 1250 lb. of pressure per sq. in. is applied to the layers of wood and resin, and then the temperature is fixed at 290° F. for 35 min., followed by a cooling period of 25 min., at the end of which time the (*Please turn to page 120*)

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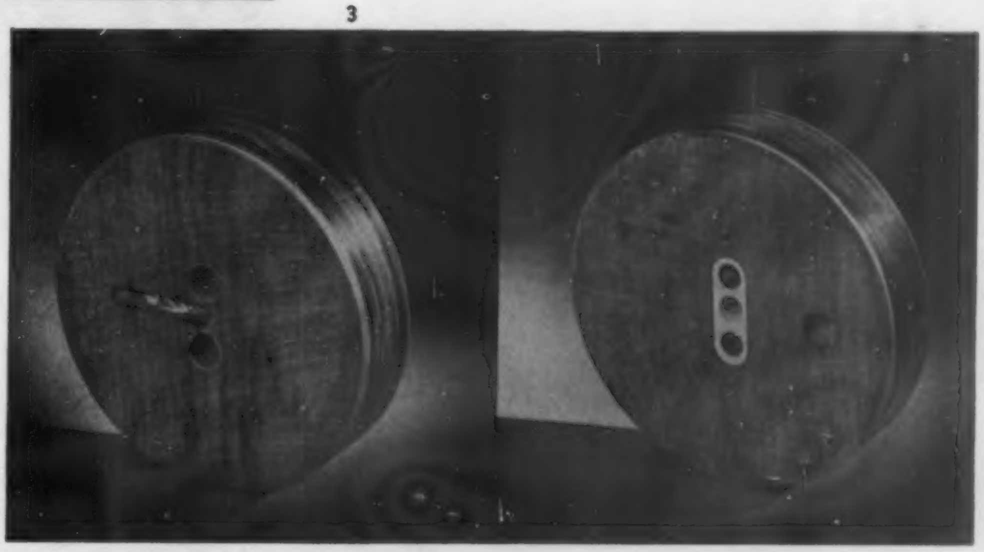
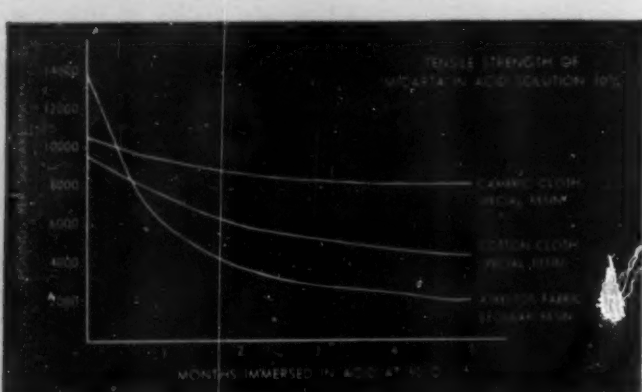


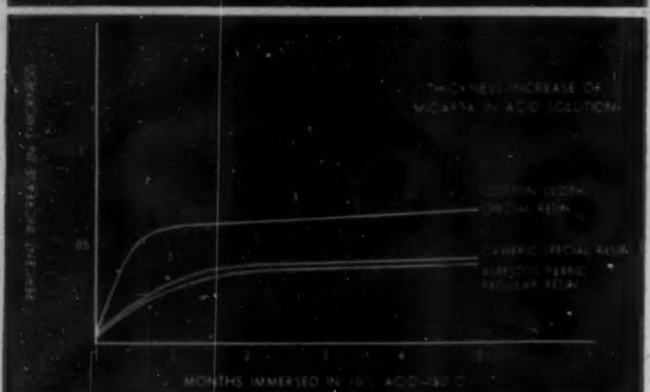
1—Hydraulic presses which once produced linoleum now make high-density plywood for parachute flare bases. 2—Machined from flat stock, bases must be beveled, routed, drilled and finished. 3—Dry film resin glue bonds over 50 plies of wood into a tough, chunky base. Holes and groove are for attaching the flare mechanism

1—*Preventing contact of metal with wet chlorine gas used in paper manufacture, this laminated-phenolic valve lasts 2 to 3 times longer than the bronze pipe it replaces.* 2—*Pipe and molded fittings of this material*

Laminated plastic pipe for chemicals

by V. E. ENZ*





As production for war increases in volume, the problem of replacing critical metals puts a new tax on human ingenuity. Of the many materials that men have put to unaccustomed uses, few have handed in such good performance records as plastics.

As a substitute for stainless steel and bronze pipe, and because of its excellent machinability, mechanical strength and acid-resisting qualities, phenolic-laminated tubing has proved very successful when used for piping chemical solutions. The tubing has a cloth base thoroughly impregnated with synthetic resin, can be made in standard iron pipe sizes (36-in. and 48-in. lengths), and straight couplings can be contrived from larger tubing threaded on the inside. The ells, tees, valves, etc., are either machined from macerated chopped molded blocks or, in some sizes, molded to shape and tapped for pipe thread.

Tests were conducted in the laboratory to determine: 1) the decrease in strength due to contact with the chemical solution; 2) physical change, weight pick-up or loss, and swelling; and 3) internal bursting pressure of the phenolic-laminated tubing.

Since in piping chemical solutions, the problem is one of handling 5 to 15 percent solutions up to 50 or 70 lb. pressure, usually at room temperature, there are all sorts of combinations that must be provided for. Tests have shown that the laminated phenolic material can be used in a good many cases. When stainless steel and bronze pipe (silica bronze) were no longer available, they were replaced with pipe of laminated-phenolic, and the plastic was found to outlast anything that had ever been tried for these applications. In some cases, the plastic pipe had about three times the life of the bronze. The following brief citations of the successful use of the laminated-phenolic material will suggest other possibilities for its application. (*Please turn to page 120*)

* Micarta Div., Westinghouse Electric and Manufacturing Co.

3, 4—*Diagrams indicate tensile strength of laminated plastic immersed in acid at 50° C.* 5—*Increase in thickness resulting from several months' immersion in this solution*

The office record speaks

PHOTOS, COURTESY SOUNDSCRIBER CORP., CARBIDE & CARBON CHEMICALS CORP.

THE cumulative effect of modern science applied to office equipment is fast reducing office routine to a series of mechanical movements, and it may be that before long so familiar a phrase as "take a letter" will be an obsolete expression. The use of recording machines for dictation has become increasingly widespread in recent years, and plastic materials and plastic parts have contributed much to progress in this field. But the successful application of plastic materials to the dictation record itself is a relatively new development,[1] with important progress just being charted.

One manufacturer of an office recording machine, forced to seek an alternate material to replace aluminum previously used for recording disks, conducted extensive experiments in his quest for a plastic material that would be suitable for embossed groove recording. The material sought had to be a first-rate embossing medium, one that would retain the groove formed by the stylus without springing back and decreasing the depth of the groove. A shallow groove causes a loss in the quality of the recording because the high frequency of the recording varies directly with the depth of the groove. With many of the plastic materials tested, the springing back continued over a period of time, which eventually resulted in the record's losing its recording level entirely. Hence a rigid material which would produce a wall of high stiffness and strength was essential.

Another vital objective was to obtain a material that would stay reasonably flat both before and after recording so that satisfactory tracking could be produced. Any means that could be developed to hold it flat while reproducing, if such means pressed hard enough to iron out small, abrupt irregularities in the material, injured the record itself. Such irregularities give rise to distortions and groove jumping, particularly if the plastic material is of the kind which is inclined to dry and stiffen with time. Therefore the material had to be relatively free from volatile plasticizers. And finally, the material had to be of sufficient strength and thickness to permit normally rough service handling.

The records finally developed are made of vinyl copolymer resin. They are cut from press-polished sheeting, 0.010 in. thick, which are embossed 200 grooves to the inch with a diamond-tipped stylus, on both sides of a 7-in. disk. This plastic material not only fulfilled all of the basic requirements set up, but contributed other significant advantages to the finished recording disk into which it was fabricated. The records manufactured from this material are light in weight, but sufficiently rigid for use. It is also reported that this material imparts a degree of realistic clarity, and makes possible reproductions with a minimum (*Please turn to page 108*)

[1] See Modern Plastics, Feb., 1942, p. 42.

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***1**—The modern secretary takes her dictation comfortably and easily from the compact transcriber shown at right. **2**—The wafer-thin disks are 7 in. in diameter and practically indestructible. Each disk plays 30 min., 15 min. on each side. One hundred vinyl disks containing about 50 hours' dictation can be filed in a space of 7 in. by 7-in. by 3 3/4 inches. **3**—The Toneband, constructed entirely of cellulose acetate and steel, replaces the conventional earphones*

A career in plastics

Throughout the country, the growing interest in plastics is reflected by the increasing number of colleges and special training schools adding the study of plastics to their curricula

PHOTOS, COURTESY PLASTICS INDUSTRIES TECHNICAL INSTITUTE

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NO new lands to explore or obscure territories to discover? Perhaps not—but to scores of young people now engaged in the search for a postwar career, the plastics industry, with its meteoric development and its still unplumbed possibilities, seems to be an acceptable substitute. And the growing interest on the part of young people in search of a career in plastics is reflected by the rapidly expanding list of universities, colleges and specialized technical institutes throughout the country where the study of plastics has become a significant part of the curriculum in recent years. Today almost every major college from Maine to California includes a treatment of the subject of plastics, either as a self-contained course of study or an adjunct to a general course of study such as chemical engineering, design, construction, etc.

In the following survey a representative number of schools in various parts of the U. S. and Canada have been listed, with a brief description of the nature of the course offered and the laboratory equipment available:

The *University of Alabama*, at Tuscaloosa, offers a one-semester course in the chemistry of plastics. The course is almost entirely theoretical with no laboratory work except for a few informal tests made from time to time. This course is given in the spring and summer terms only.

In Los Angeles, Calif., a complete course in the theory of plastics and practices of the plastics industry is available at the *Plastics Industries Technical Institute*. The course of study begins with a consideration of the fundamental principles of the subject and continues through practical applications under commercial conditions. Complete laboratory and shop equipment, standard and laboratory size molding presses, of the same type used throughout the industry are available. The equipment includes a 50,000-volt transformer that indicates whether a plastic material has the desired electrical properties; a testing machine to measure the tensile and compressive strength of a part; a flow

3

1—Laboratory and shop work is important for the plastics student. Here is a standard injection molding press for practical experience. 2—Fabricating equipment for first-hand study of technique. 3—Standard unit for testing flow of plastics

PHOTOS, COURTESY VIRGINIA POLYTECHNIC INSTITUTE (TOP) AND BOSTON TECHNICAL INSTITUTE

tester to record the creep and flow of the material used; a light cabinet for accelerated aging that checks the permanency of colors and shows in advance the effect of outdoor exposure, a walk-in "cold box" to test temperature resistance, etc.

Plastics Institute Study Forums have also been established in various industrial centers, where students may enroll for two evening lectures a week for twenty weeks. No laboratory work is offered at these Forums. Study Forum offices are located in Oakland and Burbank, Calif.; Bridgeport, Conn.; Chicago, Ill.; Detroit, Mich.; St. Louis, Mo.; Newark, N. J.; Cleveland, Ohio; Philadelphia, Penna.; Milwaukee, Wis.

In addition to the comprehensive residence course, and the local study forums, the Plastics Industries Technical Institute offers a basic course in plastic theory for home study in the form of lesson assignments sent by mail.

At the *University of Delaware*, in Newark, a course in the theory and technology of plastics covers both aspects of the subject. In the theoretical lectures, the physics and chemistry of plastics are discussed. In the technological treatment, the underlying technological principles of industrial practices of plastics are treated. A small molding press is part of the university equipment.

The *School of Design* in Chicago, Ill., offers a course embracing both the theoretical and practical aspects of plastics in product design. Students design and execute in plastics objects such as tactile charts, jewelry, tool handles, etc. Work has also been done in furniture design with plastic-bonded plywood as the medium. A plastic design course for evening students is being introduced this fall.

At the *Illinois Institute of Technology*, in Chicago, a course in synthetic plastics encompasses a summary of various synthetic organic plastics, methods of preparation for molding and actual molding processes. In the laboratory, students are expected to prepare and study at least eight different plastic materials, not only from the point of view of the preparation of the material, but also from that of molding, compounding with customary fillers and molding with fillers ordinarily used in industry.

Projected for the fall semester at the *University of Louis-*

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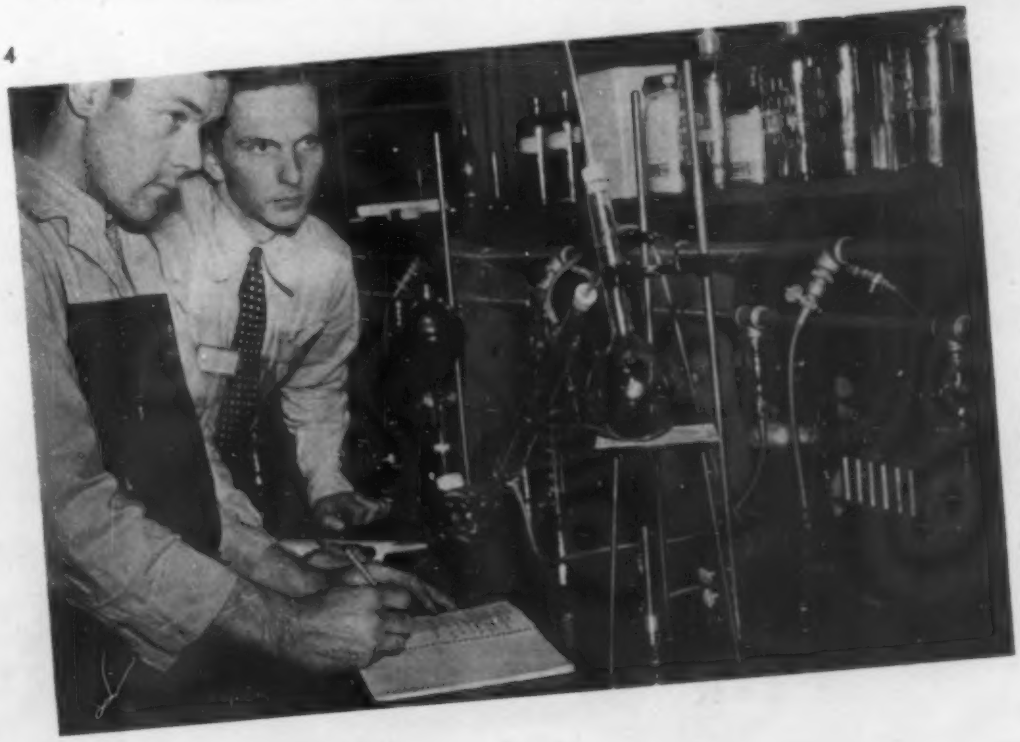
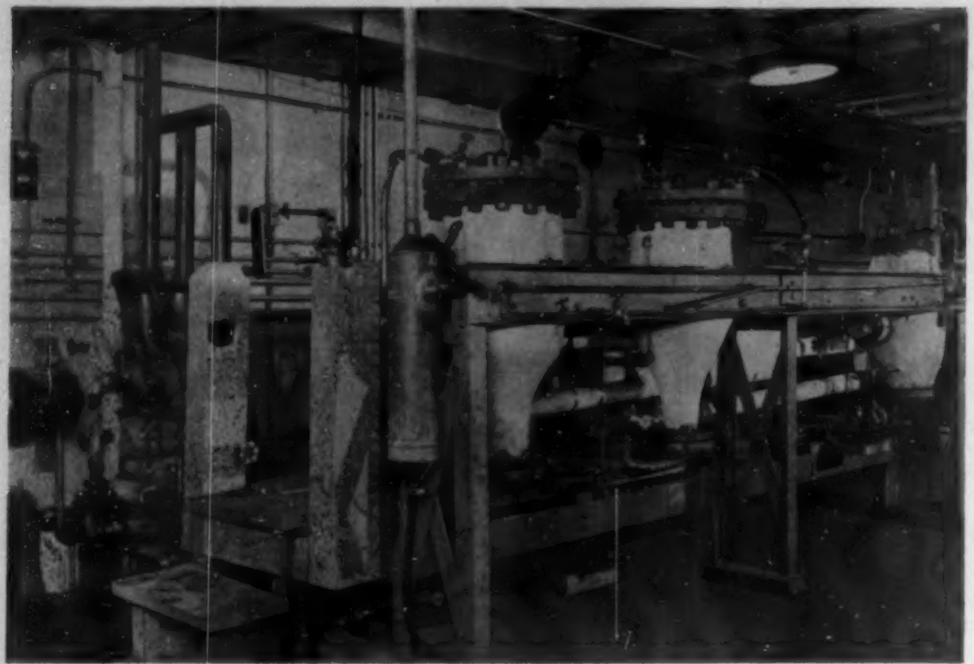


4—A well equipped laboratory encourages chemical research and experimentation with new ideas and materials. 5—Drafting room where planes and angles are translated into plastic objects by budding craftsmen and designers. 6—Students test plywood in wood research laboratory under scientifically controlled conditions

PHOTOS, COURTESY OF N. Y. STATE COLLEGE OF FORESTRY, SYRACUSE UNIVERSITY AND MISSOURI SCHOOLS OF MINES & METALLURGY



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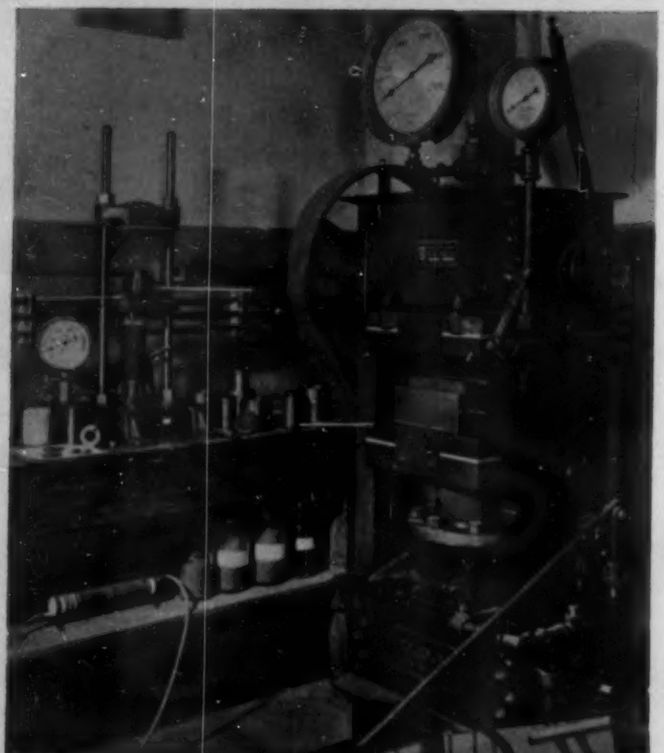
***7**—Stainless steel digesters equipped with outside circulation and heat exchangers used for research in acid pulping of wood and autoclaving of wood waste for lignin plastics.* ***8**—Hydraulic press and dies are essential laboratory and shop equipment.* ***9**—Plastic samples are molded on small laboratory press and tested*



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ville, in Louisville, Ky., is a course for graduate students in high polymeric substances, developed to meet the needs of the local community as related to paint, rubber and plastic industries. No laboratory work will be offered to begin with, although a small hydraulic press, a laboratory press, and a small experimental molding press are among the laboratory equipment available at the university.

In Boston, Mass., the *School of Plastics,* division of the Boston Technical Institute, offers a complete course of study and laboratory courses covering the study of basic industrial plastics (lecture classes); chemistry of synthetic resins (lecture and laboratory); plastics mold design (lecture and drafting room classes); plastics engineering, covering industrial production of plastics, plastic chemistry, molding and testing of plastic materials; industrial production (lectures and laboratory); and plastics industrial and aircraft fabrication (shop). Facilities include a drafting department, molding and testing equipment, a fabrication shop and laboratory for industrial production of plastics.

The *Technical School for Plastics Industry,* also in Boston, offers several courses combining theoretical and practical elements, for both day and evening students. Plastics in industry, chemistry of plastics, mechanics of plastics, plastics engineering are among the courses given. The visual method of instruction is employed, with problems projected on a screen to accompany lectures.

Michigan State College, East Lansing, offers to senior students in organic chemistry two courses in plastics. The first, given in the winter term, is a lecture course on polymerization, which provides the background for a spring laboratory course. No attempt is made to present plastics from a technical point of view such as molding, fabricating or working such materials, and the laboratories are equipped to present the subject of plastics from the standpoint of the organic chemist with emphasis on theory and reaction.

Two courses in plastics are offered by the *University of Michigan,* in Ann Arbor. One is a classroom and seminar course open to advanced students which covers the field of plastics from standpoint of physical and chemical properties as involved in the production of various plastics and in their application. The other is a laboratory course dealing with

special problems and with research in the field of plastics. Laboratories are equipped with mixers, rollers, a 20-ton hydraulic compression press for thermostatic control, electric platens and subsidiary equipment such as cooking vessels, etc. Additional work is offered to advanced students in the use of plastics as engineering material in connection with other courses not specifically limited to the field of plastics.

At *Wayne University*, in Detroit, an elementary course under the sponsorship of the defense training program is being offered at present. Projected for the fall semester is a regular collegiate program which will include a beginning survey course (no laboratory), followed by an advanced theory and testing course with full laboratory work. The establishment of a complete laboratory at this university has recently been undertaken by the Detroit Rubber and Plastics Group.

In New York City, the *College of the City of New York* offers a lecture course in plastics and related materials called organic constructional materials which includes consideration of processes and manufacturing methods used in production of plastics, resins, rubbers, fibers and paints. Correlation of the structure, physical and chemical properties, and applications of organic constructional materials are also included. The course will be offered only for the day session during the fall semester, and for day and evening for the spring 1943 semester.

At *Columbia University* in New York City, a course in synthetic plastics is offered to graduate students and men in the industry. It covers a discussion of the various synthetic plastics, their chemistry, manufacture and properties, together with modern design of plastic products and molding equipment to take advantage of the time- and labor-saving features of these engineering materials. For men interested in plastics research, library and laboratory facilities are available, as well as equipment for production, fabrication and testing of synthetic materials. A discussion of plastics is also included as part of courses in dentistry.

Beginning in September, *New York University*, in New York City, will offer a graduate course which will cover the field of plastics both as to synthesis and use. A graduate course in unit processes of organic synthesis in which certain fundamentals concerning the synthesis of plastics are treated is also being given. There is no specific laboratory devoted to the plastics department, but both the organic chemistry and chemical engineering laboratories have equipment which could be used either in the synthesis of plastics or in their utilization.

At the *Polytechnic Institute of Brooklyn*, in Brooklyn, N. Y., a course is offered on the technology of resins and plastics. The sources, production and testing of the more important resins and plastics in current use are covered, with special attention to the phenolic resins, urea resins, acrylic resins, vinyl resins and styrene resins, as well as to cellulose esters and ethers, regenerated cellulose, casein and shellac plastics. Sources of raw materials will be discussed as well as the use of fillers, plasticizers, dyes, lubricants and accelerators in molding, lamination, preform molding, impregnation, coating and in the production of synthetic fibers and elastomers. A comparison is made of the various materials in individual uses, and an introduction is given to the design of products fabricated from plastic materials. The course is given two hours a week during the fall and spring terms, and is offered in alternate years. It will be given in 1942–3, beginning with the fall term.

A complete course of study covering the theoretical and practical application of plastics to industrial design is offered at *Pratt Institute*, in Brooklyn, N. Y. The school is equipped with facilities for the practical handling of plastics, and is installing a new compression molding press for the next semester.

The *New York State College of Forestry*, at Syracuse University, offers a course of graduate character in plastics chemistry, called plastics and cellulose technology. Emphasis on the fundamental underlying chemistry of plastics is stressed. The college has a plastics research laboratory offering research facilities to graduate students for work on the development of cellulose derivatives, lignin and wood plastics.

At the *Rensselaer Polytechnic Institute*, in Troy, N. Y., the course in plastics covers the following fields: the chemistry of the important types of plastics; the commercial production of these types; the properties and engineering uses of plastics; the fabrication of articles from plastic materials—molding, etc.; laboratory work on the preparation and study of phenol formaldehyde resins, urea, thiourea, melamine-formaldehyde resins, alkyds, methacrylates, styrene, vinyls, cellulose derivatives, coumarone-indene, *(Please turn to page 118)*

***10**—A corner of this school laboratory shows a 2-hp boiler (left) which generates steam for mixers, molds and reactors; and mill (right) for grinding fillers and molding compounds.*
***11**—This mechanism controls temperature and humidity conditions within 25° to 80° C. range*

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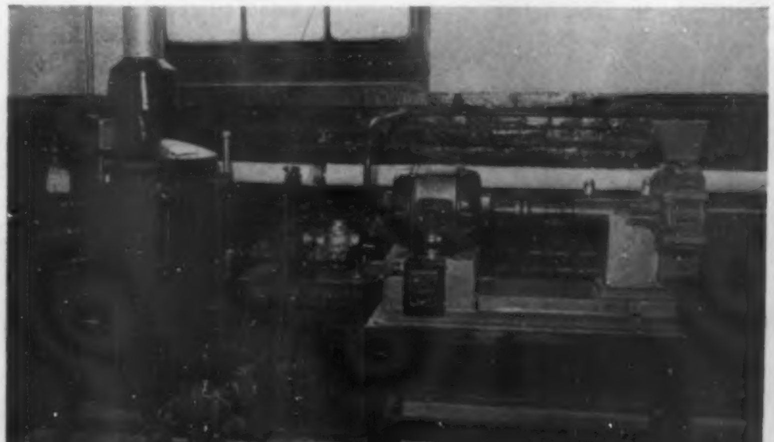

11

PHOTOS, COURTESY CASE SCHOOL OF APPLIED SCIENCE

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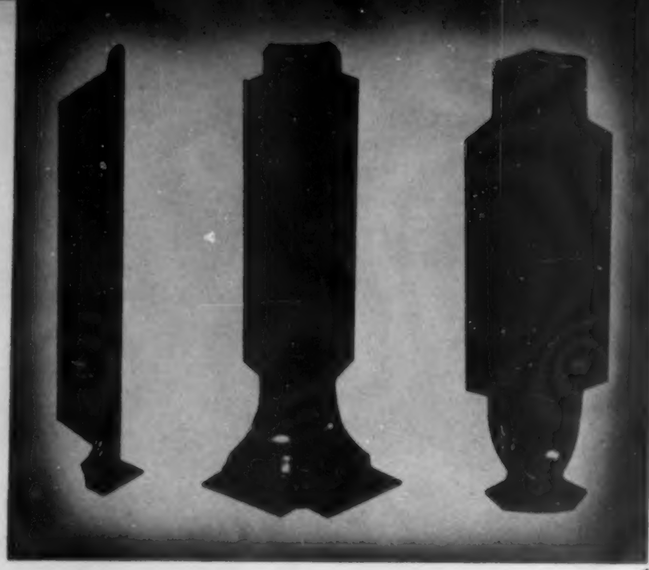

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1 Extruded plastic trim in bright decorative hues now provides a durable finish for Armstrong Cork Co.'s linoleum installation. Available in six colors to harmonize with interior decor, the trim is made from Tenite II in a variety of shapes suitable for binding strips, cap strips, inside and outside corners and right and left end strips. Easily installed (merely shaved with a knife to fit and nailed to wall) and economical, the new trim is flexible

2 Marks made by a temperature-indicating crayon on iron, steel and like materials before they are welded, melt when the desired degree of heat has been reached. Made by the Tempil Corp. of Bakelite cast phenolic, Tempilstik is available for temperatures between 125 and 1400° F. Each stick signals one temperature only and is good for 1000 applications

3 Designed to withstand concussion of depth bombs and gunfire, these 25- and 50-watt rheostats are molded of Durez by International Resistance Co. The units are said to remain unaffected by temperature extremes, and the material itself is endowed with high dielectric properties

4 Ban to occupational diseases contracted by surface contacts with the skin are oil-and solvent-proof gloves, aprons. Made of tough, flexible material with high resistance to tearing and abrasion, coated with a film of Resistoflex PVA

5 Tenite replaces brass in the manufacture of this air-flow control unit for blood pressure instruments. Molded by Bridgeport Molded Products, Inc., for W. A. Baum Co., Inc., the plastic parts (at right) weigh less than $^1/_4$ as much as former brass fittings—an important advantage for portable medical equipment, especially for the armed forces

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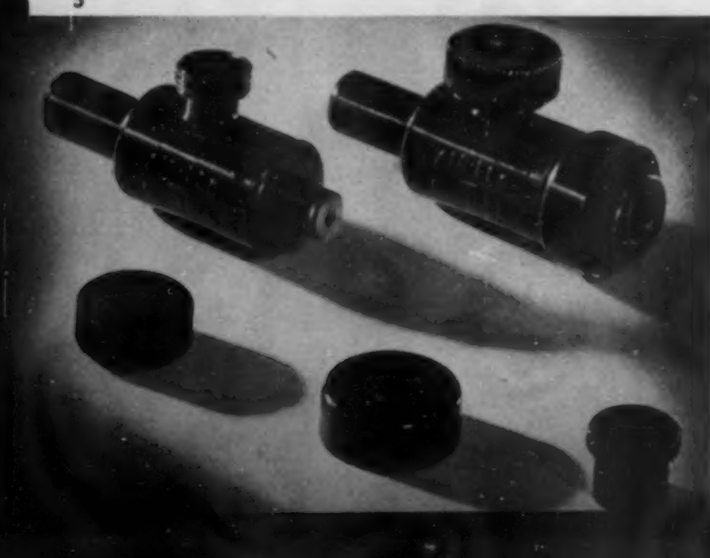

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6 To obtain precise optical data, the transparent Dispensometer is placed before the patient's eyes with the bridge contour resting on his nose, and both horizontal and vertical pupillary measurements read with ease and accuracy. Molded of Lucite by Recto Molded Products, Inc., for Ocular Products, the device may be easily cold sterilized

7

7 Milady can cut a fine figure in Nina Fay's girdle of cloth and ribbon reinforced with Lumarith stays. The stays, sufficiently diversified in breadth, thickness and length for every figure, are extruded by R. D. Werner Co., and are reported to be superior to metal because they are rustproof, flexible, have no sharp edges and will wash perfectly

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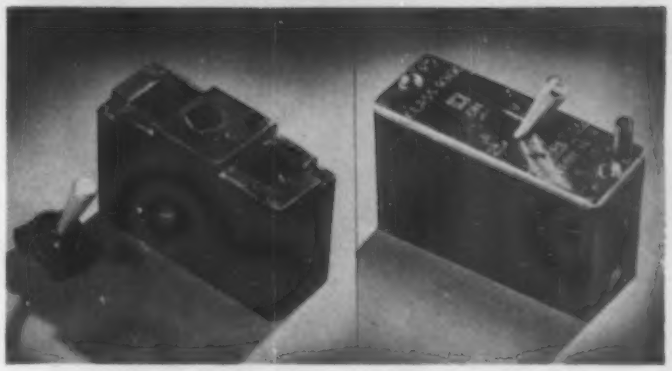

8 In military aircraft turret and gun control, in tanks, and everywhere that there is action these days, the circuit breaker is doing an important job. This one is molded of Durez by Square D Co. High dielectric properties of the phenolic material, its immunity to shock and temperature change, make it highly suitable for precision units

9 An important feature in any cream separator is its lubricating system. The combination oil viewer and filler cap (below) for the McCormick-Deering unit enables the operator to see at a glance when oil should be added. Injection-molded in one piece of transparent Lucite by Chicago Molded Products Corp., the cap won't corrode and is highly resistant to breakage

10 During stratosphere flights, this aviation "breather" feeds oxygen to the pilot as the plane gains altitude. Fabricated of Catalin rod by Plastic Turning Co. for United Airline Transportation Co., the small curved stem is odorless and tasteless

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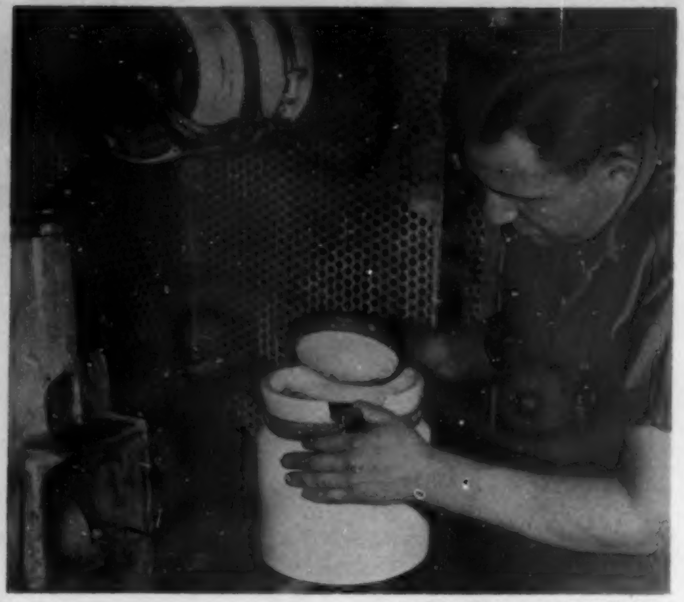

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PHOTOS, COURTESY RESISTOFLEX CORP.

Synthetic resin replaces rubber

Polyvinyl alcohol compounds outlast and outperform scarcer material in widely varied applications

WHILE millions of American motorists are finding the rubber shortage annoying and a source of inconvenience, the majority can if necessary get by until the synthetic rubber industry is able to meet their needs, even if it takes two years or more. In industry, however, the situation is much more critical. Many rubber parts are used on machines turning out vital war supplies, and stopping any one of these machines means fewer weapons for the United Nations armies.

Industry's answer to this situation has been to conserve rubber and to substitute other rubber-like materials wherever possible. The RCA Manufacturing Co., which is highly dependent on rubber in many of its manufacturing processes, started farsightedly experimenting with one of these—a polyvinyl alcohol compound—a little over a year ago. Today it has supplanted rubber and synthetic rubber with this compound in over fifteen separate applications, and in nearly every case the "substitute" is outlasting and outperforming the original material.

Polyvinyl alcohol compounds have certain rubber-like physical characteristics such as pronounced flexibility, elasticity and resiliency. The basic material from which the polyvinyl alcohol plastic products are made, in various types and viscosity grades, is a powdered white or yellow resin. Until compounded or partly processed this material is neither thermoplastic nor thermosetting, differing in this respect from most of the materials generally classified as organic plastics. With proper handling, it can be molded to shape.

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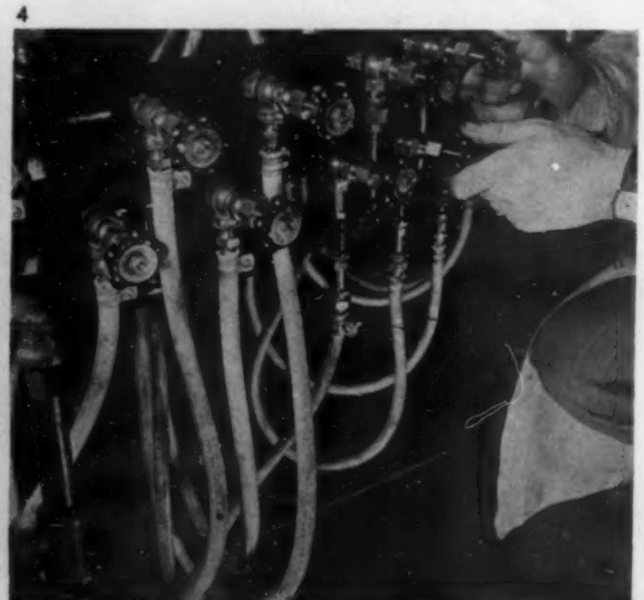

The processes for molding and shaping polyvinyl alcohol partially parallel the technique of the plastics industry and partly are modifications of those common to the rubber industry. The material differs from the rubbers, in many ways, including the fact that it does not require vulcanization.

Preliminary investigation proved that products made of this compound were highly resistant to the many solvents that attacked the rubber used in the manufacturer's various metal cleaning and other manufacturing processes. These involved the usual carbon tetrachloride, trichlorethylene, acetone and many others. Further tests showed that the new tubing would convey hydrogen, oxygen, nitrogen, illuminating gas and air as effectively as rubber. Such tubing has since stood up for months even though saturated with hot oil and subjected to continuous flexing at a rate of about six hundred times an hour it is reported.

A typical example is flexible gas-air lines (Fig. 4). In the manufacture of radio tubes a great number of processes involve the use of gas fires. Since the burners of the machines are frequently in motion and always adjustable, a flexible connecting medium is required to convey the gases from the fixed manifolds to the movable burner piping. Time-honored custom had made rubber tubing standard for this purpose.

Similarly, the many connectors between valves, traps, pumps, gages, etc., on evacuating and sealing machines consisted of molded sections made from almost pure gum rubber.

Another advantage offered by tubing of polyvinyl alcohol compound was the fact that the basic compound from which the tubing is made could be varied to meet the particular requirements of specific applications. Thus when RCA first started experimenting with the material, engineers of the corporation manufacturing it formulated a special compound to meet the user's needs, and fabricated from this a cotton covered hose (Fig. 4) especially adapted to his processes.

Installations of the new hose are made with little or no change in machine design. In fact, in some cases it has eliminated the need for extending pipes as called for by another phase of the rubber conservation program. Only a comparatively few sizes are stocked to match the standard pipe nipples used, and in this respect it is equally as adaptable as the original material.

In addition to replacing rubber with the new compound, RCA is also to a large extent using tubing of this type to displace flexible metal hose, generally made of brass, copper, stainless steel, etc. In certain instances even conventional copper tubing and fitted piping are also being so displaced.

(Please turn to page 132)

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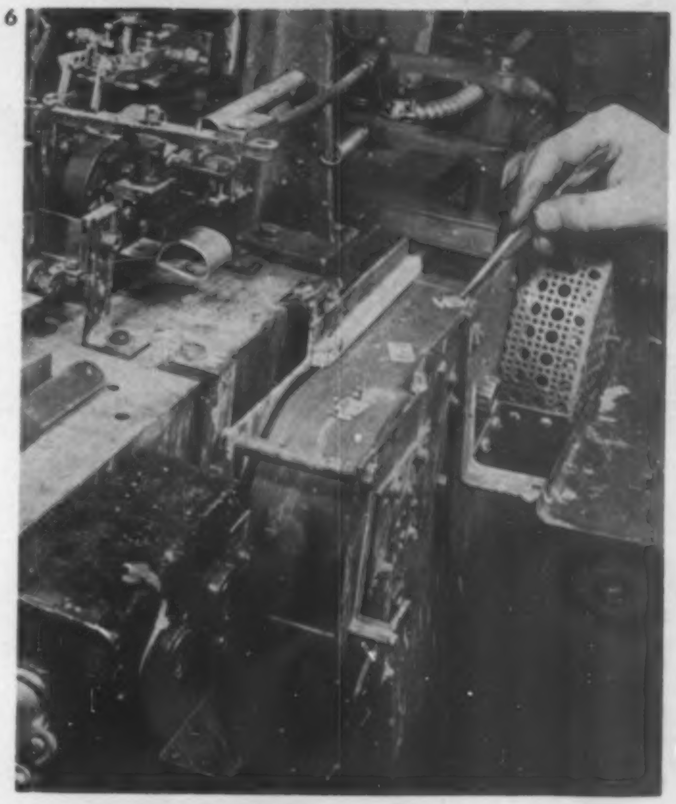

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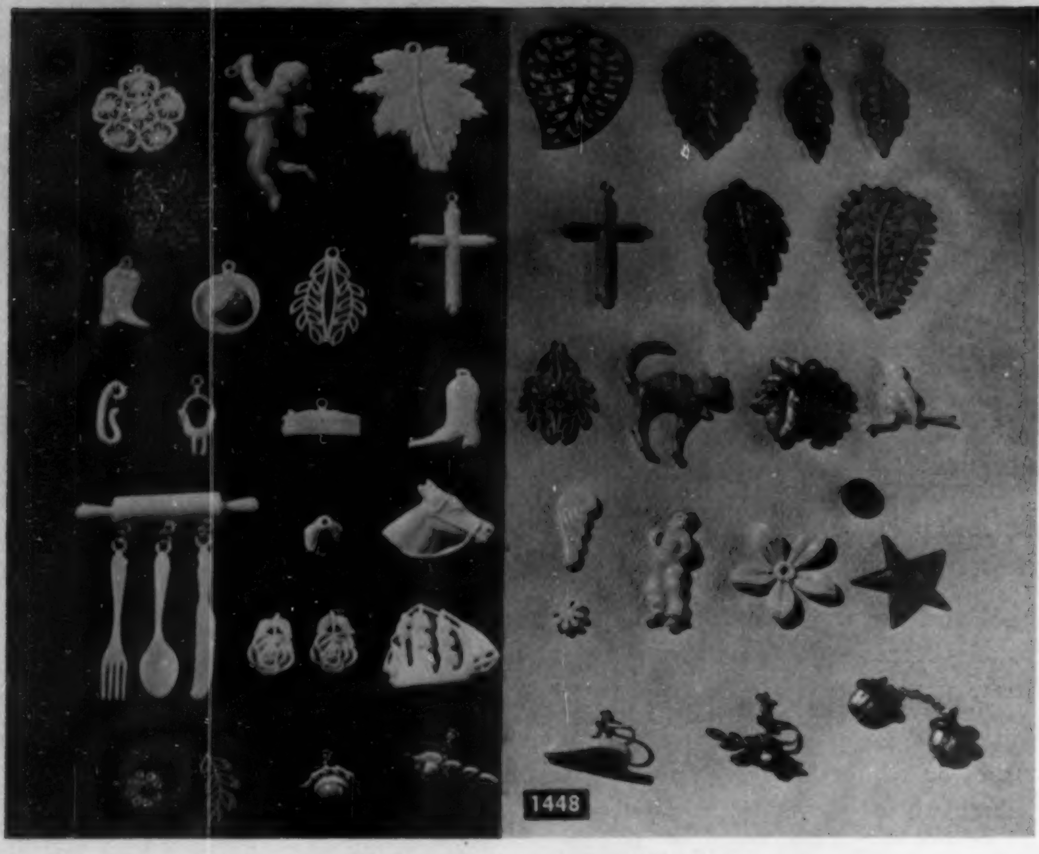
***1**—Chemical and oil-resistant polyvinyl alcohol compositions have been put to work replacing rubber in industrial machinery and tube manufacture. Here a workman cuts a ball mill gasket from a sheet of this material. **2**—He affixes it to seal a ball mill jar cover prior to its being placed into the rotating unit. **3**—A rolled sheet of the plastic is made into a suction line tube on a sandblast machine. **4**—Resistance to flexing and vibrations is demonstrated in a gas and air line connection on an automatic machine. The synthetic resin hose has a braided cotton outer jacket. **5**—Wrist shields for operators of sandblast machines are abrasion-resistant and durable. **6**—A conveyor belt of the material replaces one of woven wire on a machine for making small parts. **7**—Transmission rings which rotate against metal gears to furnish power are also being made from polyvinyl alcohol compositions*



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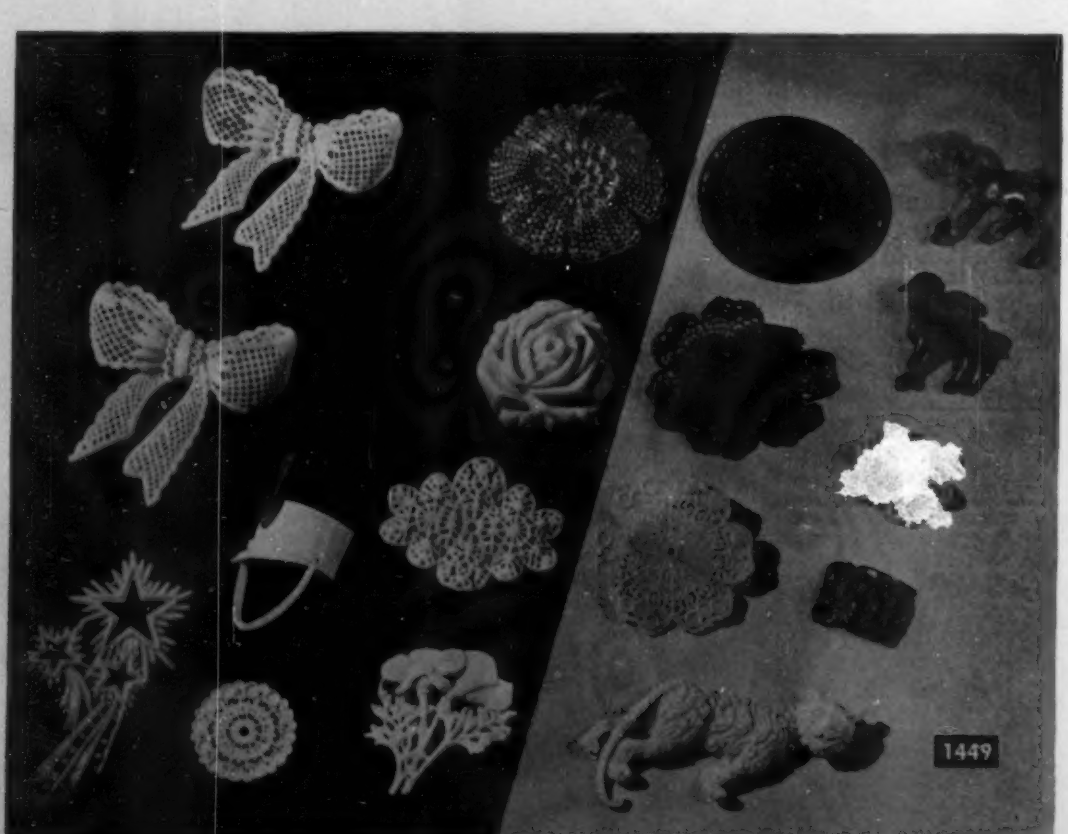

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DR. GORDON M. KLINE, Technical Editor

Creep tests on cellulose acetate*

by WILLIAM N. FINDLEY[1]

IT IS known that many plastics undergo considerable deformation over a period of time as a result of sustained loads of relatively small magnitude. This deformation may continue until fracture takes place if the loads are maintained a sufficient length of time. In a previous paper the effect of stress on the time required to cause fracture of cellulose acetate under a constant applied load was shown.[2] It was found that fracture took place after a period of time even for stresses far below the ultimate strength as determined from a short-time tension test.

The present tests are a continuation of the tests mentioned above. The tests reported herein concern the effect of time on the deformation of cellulose acetate when subjected to a constant tensile load for periods of time up to 7000 hr. (about 10 months) and at various stresses—the phenomenon of "creep." Two other investigators have studied this phenomenon for different types of loading. Bartoe[3] has studied the effect of a steady compressive load on methyl methacrylate for periods of time up to 1000 hr. Delmonte and Dewar[4] have studied the effect of a steady bending moment on several plastics for periods of time up to 100 hr. at various temperatures but at only one stress, 1000 p.s.i.

Material and test specimens

The material[5] for these tests was supplied by the Plastics Division of the Monsanto Chemical Co. (Monsanto formulation number 2050TV). All specimens used in these tests were cut from the same sheet of cellulose acetate as used for the 1941 tests.

A drawing of the specimen used for these creep tests is shown in Fig. 1. The specimens were cut from the sheet of cellulose acetate with the same orientation as the specimens used in the previous tests, namely, with their axes crosswise of the sheet. All specimens were cut on a jig saw and then milled to the form shown in Fig. 1. The milled edges were then smoothed with No. 00 emery paper so as to remove all burrs and scratches transverse to the axis of the specimen. All specimens used for the creep tests were prepared at the same time, placed in the laboratory at the same time, and remained in the laboratory continuously thereafter. The laboratory was maintained at a constant temperature of 77 ± 1° F., and 50 ± 2 percent relative humidity continuously throughout the duration of the tests, about 10 months.

Testing equipment

The equipment used for conducting the tests consisted of a steel rack from which 24 specimens could be suspended, calibrated weights used for loading the specimens, measuring equipment for determining the strain in each specimen, and a clock equipped with a counter to record the elapsed time in hours. Because of the sensitivity of cellulose acetate to small changes in temperature and relative humidity, it was also necessary to provide a test room maintained at constant temperature and constant relative humidity throughout the tests.

Figure 2 shows a portion of the creep rack with apparatus set up for measuring the strain of a specimen. As may be seen the specimen, *A*, was subjected to an axial tensile load by means of dead weights, *B*, attached to the rod *C*. The specimen was held by grips, *D*, which contained a hook-and-

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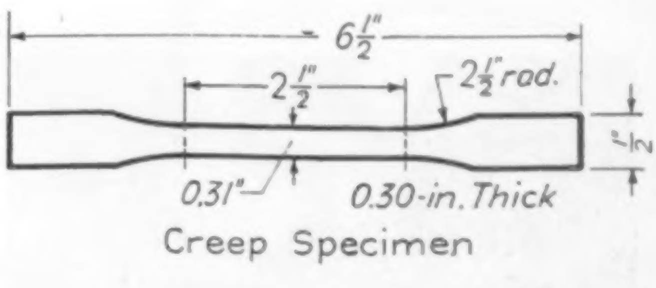

eye type of swivel joint. This joint was provided in order to minimize the possibility of bending the specimen.

The extensometer used for measuring the creep consisted of two T-shaped brass strips, *E*, clamped to the specimen with a traveling microscope (cathetometer, *F*) for measuring the displacement between fixed reference marks on the ends of the two brass strips. A track was provided for the microscope so that it could be moved from specimen to specimen quickly. The brass strips *E* were clamped to the specimen with compressed springs. These springs were necessary in order to keep the extensometer firmly attached to the specimen during the test, since a reduction of area of 30 percent might be expected before fracture took place.

The distance between the centers of the flat bars, to which the above-mentioned springs were attached, was considered to be the gage length of the extensometer. This distance was 2 in. at the start of the test. A uniform gage length for each specimen was essential for accurate comparison of tests. This uniformity was obtained by using identical extensometers and a jig to assemble the extensometer to the specimen.

Flat clamps were used to attach the extensometers to the

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* This paper was presented at the Annual Meeting of the American Society for Testing Materials in Atlantic City, N. J., on June 23, 1942, and is published here by permission of that Society.

[1] Instructor in Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill.

[2] William N. Findley, "Mechanical Tests of Cellulose Acetate," *Proceedings*, Am. Soc. Testing Mats., Vol. 41, p. 1231 (1941); MODERN PLASTICS, Vol. 19, No. 1, September, 1941, p. 57.

[3] W. F. Bartoe, "Service Temperature Flow Characteristics of Thermoplastics," *Mechanical Engineering*, Vol. 61, No. 12, December, 1939, p. 892; MODERN PLASTICS, Vol. 17, No. 7, March, 1940, p. 47.

[4] J. Delmonte and W. Dewar, "Factors Influencing Creep and Cold Flow of Plastics," *ASTM Bulletin*, No. 112, October, 1941, p. 35; MODERN PLASTICS, Vol. 19, No. 2, October, 1941, p. 73.

[5] For complete description of the material, see 1941 paper referred to in footnote 2.

specimens instead of pointed screws because creep of the material would cause screws to sink into the specimen, thus causing early failure. The flat clamps were found to yield a satisfactorily precise location of gage length inasmuch as it was found that slippage between the clamps and the specimen as a result of the stretching of the specimen was distributed equally on each side of the clamp bar.

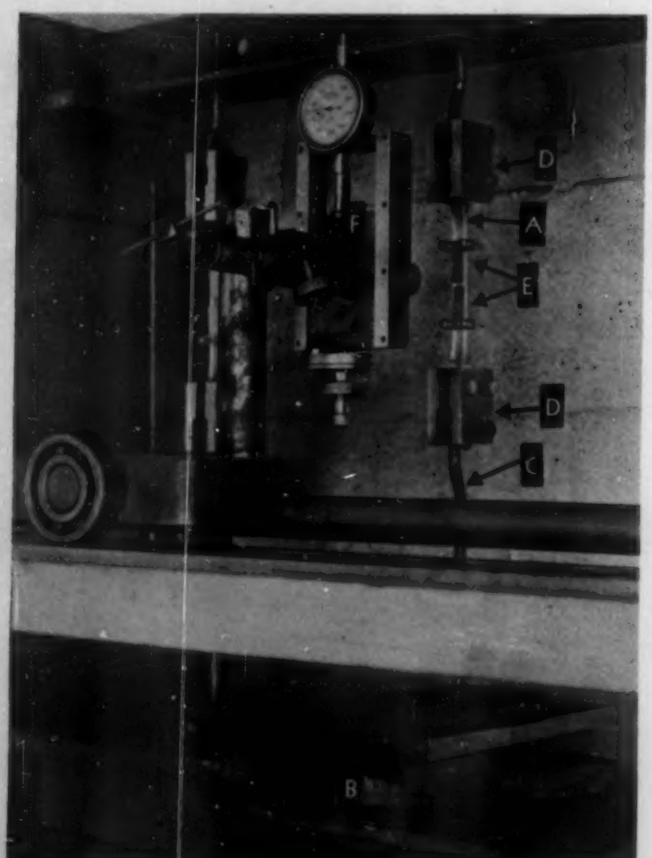
Test procedure

Twelve specimens were prepared as outlined above and allowed to remain in the atmosphere of the testing room for about 2 weeks before any tests were started. Tests were started with eight of the specimens at the same time but with different stresses ranging from 505 to 2695 p.s.i. The procedure in starting these tests was as follows:

The weights, weighing from 30 to 150 lb., were first supported on planks, blocked up in such a way that they could be used as levers to lower the weights quickly but gently until they were supported by the specimen. Before lowering the weights, the initial extensometer readings were obtained with the traveling microscope. Then the weight was lowered on the first specimen, the extensometer was immediately read again and the time was recorded. The difference between the strain computed from these two sets of readings was the elastic strain. Any further increase in strain was the result of creep. The remaining seven specimens were treated in the same way.

After all eight tests had been started, strain and time readings were taken at intervals of time, which for the high stress tests were from 2 to 12-hr. intervals until fracture. Low stress specimens were read about every 2 days for a month, then every 1 to 2 weeks. All specimens were weighed both

2—Creep testing equipment



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before the start of the test and after fracture to ascertain any change in weight.

Test results

The results of seven of these eight tests are shown in Fig. 3 where creep is plotted against time. Creep as usually defined is the total change in length (including elastic stretch) between gage points, located on the cylindrical portion of the specimen, expressed as a percentage of the original distance between gage points. For the sake of clarity the test data at 505 p.s.i. stress were omitted from Fig. 3 but are shown for the first 2000 hr. in Fig. 4. However, there was no measurable creep at this stress.

From Fig. 3 it is evident that the intermediate stresses (2008 and 1690 p.s.i.) resulted in an initial rapid rate of creep at a constant rate (referred to here as the first stage of creep) followed by a transition region (referred to here as the second transition) and then another constant rate of creep (referred to here as the second stage of creep). It is evident from Fig. 3 that the rate of creep is much slower in the second stage than it is in the first stage. An examination of Fig. 3 shows that the second stage is practically non-existent at the higher stresses (2305, 2505, 2695 p.s.i.). Also for the low stresses (1018 and 1320 p.s.i.) the second stage either is non-existent or had not yet been reached after 7000 hr. of testing.

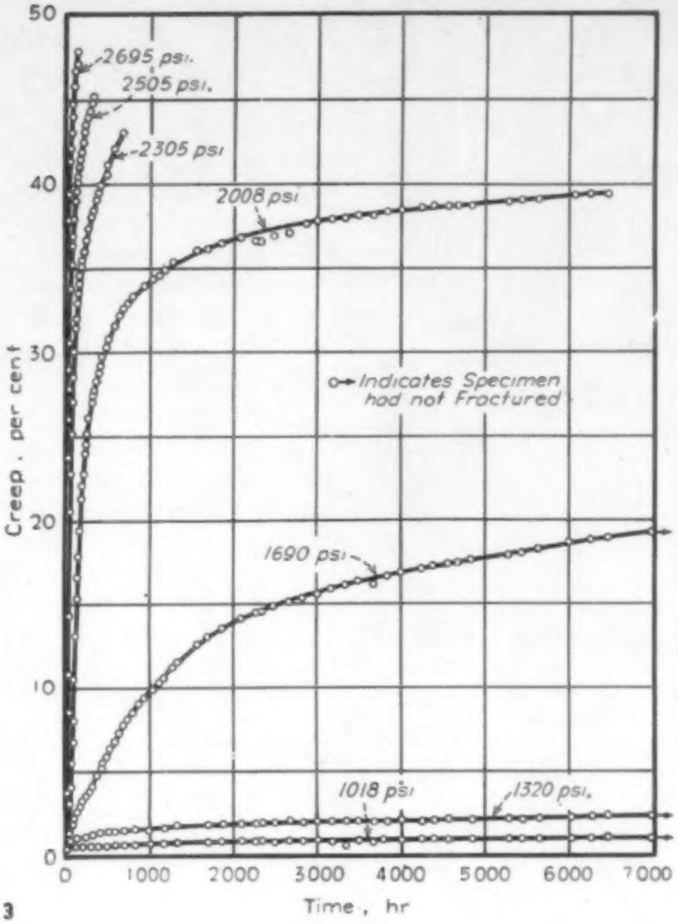
The data for the first 2000 hr. are shown to a larger scale in Fig. 4. In this diagram the data from the original set of eight specimens are shown by open circles. It is evident from this plot that there is an initial or first transition region preceding the first stage of creep. The curvature of this transition is concave downward for intermediate and low stresses and concave upward for the high stresses.

It will be noticed that no final region of increasing rate of creep occurred, such as the "third stage" of creep in metals. This is probably due to the fact that there is no localized reduction of area (necking down) just before fracture of this material, as there is for metals.

Effect of aging: After an elapse of 2330 hr. (about 3 months) from the start of these tests two more specimens were started at 1802 and 1900 p.s.i. in order to obtain more information at intermediate stresses. The resulting data are shown by the half-filled circles in Fig. 4. It may be seen that the rate of creep of these specimens is much lower than was to have been expected on the basis of the first tests. For example the data for both tests of this second group (1802 and 1900 p.s.i.) fall below the data for the 1690 p.s.i. test of the first group. Also it may be seen that the character of the initial transition has changed slightly from that observed in the first set of tests.

The differences in behavior of these two sets of tests can only be the result of the elapse of time between the start of the first tests and that of the second tests (aging) because all other conditions were held constant. All specimens were made at the same time from the same sheet of acetate, and had been in the air-conditioned laboratory the same time. By aging is meant a change in the mechanical properties of the material with time. Possible causes might be slow change in moisture content, residual solvent content or plasticizer.

In order to study this phenomenon further, tests of the remaining two specimens were started 5260 hr. after the start of the first test, at stresses of 1690 and 1900 p.s.i. The specimen used for the first test at 505 p.s.i. was also changed to a stress of 2305 p.s.i. (The specimen had not shown any creep at the 505 p.s.i. stress.) The data for these tests are represented by the solid circles in Fig. 4. It will be noticed that the rate of



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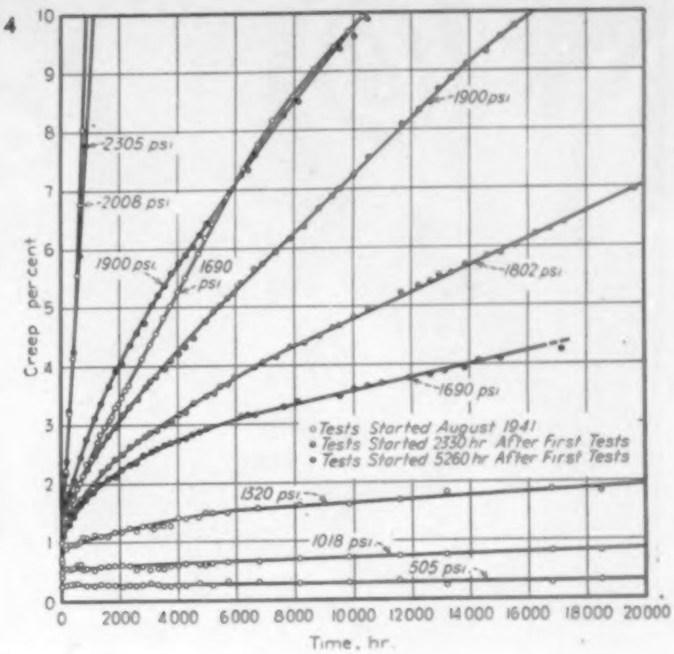

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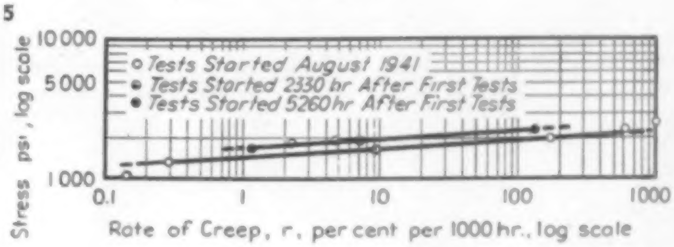

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3—*Creep-time diagrams, 7000 hr.* 4—*Creep-time diagrams, 2000 hr.* 5—***Effect of stress on rate of creep, log scale***

creep for these tests is much less than that for the first group but is greater than the rate of creep for the second group of specimens. No explanation can be offered for this apparent reversal in the effect of aging and a further study of the effect is not possible because of a lack of specimens which have had a parallel history.

Weight measurements of specimens of the cellulose acetate show a decrease of about 0.6 percent in weight during the period of creep testing, about 7000 hr.

Effect of stress: The effect of stress on the creep of the cellulose acetate is better shown by Figs. 5 and 6.[6] Figure 5 shows a double logarithmic plotting of stress against rate of creep (for the first stage of creep). The rate of creep is obtained as the slope of the curves shown in Fig. 3 or Fig. 4 for the first stage, as defined above. It will be noticed that the data for the first group of tests, shown by the open circles, fall on a straight line, except at the two extremes where measurement of the rate of creep was uncertain. The data for the second and third group of specimens are also shown by half-filled and filled circles, respectively. These data also fall on straight lines which are parallel to the first.

Data, such as these, which yield a straight line on double logarithmic plotting may be represented by an equation of the form

$$S = m \cdot r^n$$

where:

S = the stress,
r = the rate of creep,
n = the geometric slope of the line, and
m = the value of the stress corresponding to a rate of creep of one.

This equation for the first group of tests is $S = 1440r^{0.065}$.

An examination of Fig. 5 shows that aging changes the constant in the above equation but does not change the exponent.

In Fig. 6, stress is plotted against the creep occurring in a certain time interval. Curves for time intervals of 200, 2000 and 6000 hr. are shown. It may (*Please turn to page 114*)

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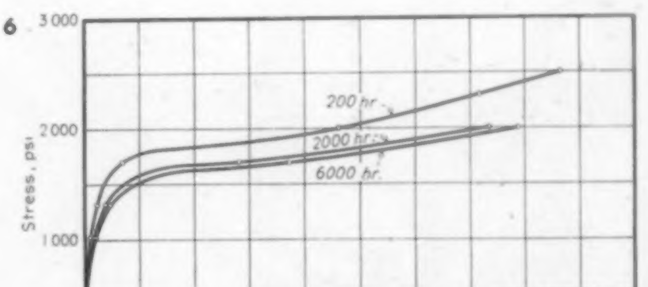
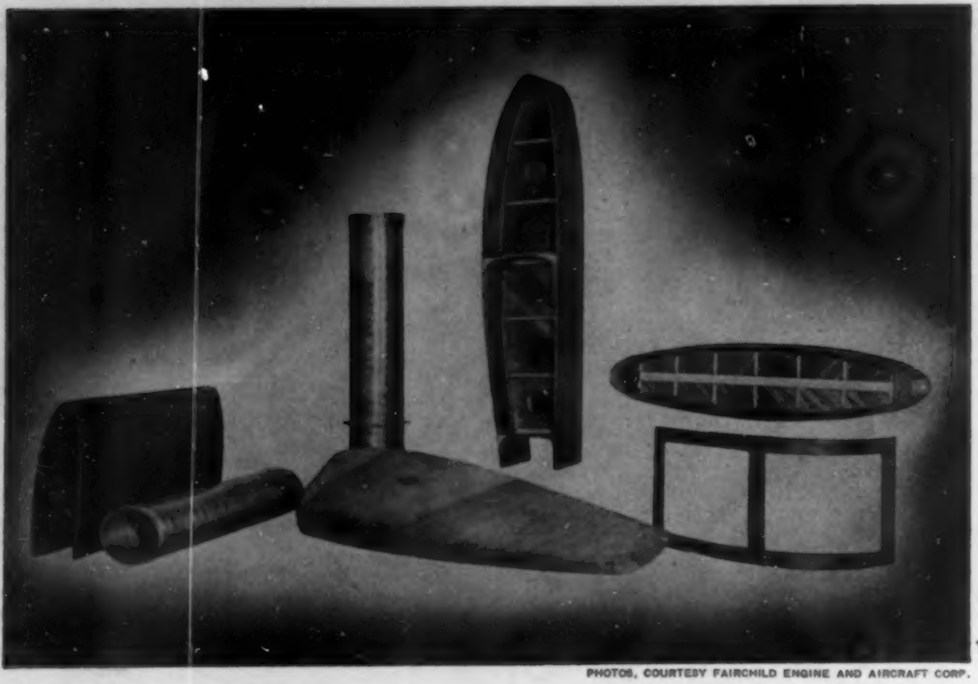


6—***Effect of stress on creep for 3 different time intervals***

[6] P. G. McVetty, "The Interpretation of Creep Tests," *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part II, p. 105 (1934).
H. F. Moore, "Materials of Engineering," Sixth Edition, p. 37, McGraw-Hill Book Co., Inc., New York, N. Y.



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PHOTOS, COURTESY FAIRCHILD ENGINE AND AIRCRAFT CORP.

1—Advances in gluing technique made possible by the use of synthetic resins have expanded the use of plastic-plywood for many structural parts formerly made of metal. The various pieces shown are made by the bag-molding process under heat and pressure. Note unusual contours and complex shapes. 2—Interior view of a large plastic-bonded structure

Strength of plastic-bonded plywood*

by GEORGE B. PARSONS†

WHEN, a few years ago, engineers made possible the production of aluminum in quantity at low cost, the aircraft designer decided that here finally was the perfect material for which he had been searching. So great was the swing from wood to aluminum that the former was almost completely forgotten.

With the present situation demanding immediate production of an almost unbelievable quantity of planes, the aviation industry finds itself confronted with a problem of increasing scarcity of material. All around one hears the cry, "Give us the aluminum and our production will go up fifty percent." The granting of this request is an impossibility, so aircraft designers have had to turn once again to wooden structures and rationally investigate the part that they can play in the present crisis. The trend in most cases has been toward the use of plastic-bonded plywood for non-structural parts such as flaps, ailerons, tail cones, or any compound curvature parts that have presented trouble to the manufacturer.

New methods of molding plywood with new adhesives have opened an entirely new field in which possibilities are unlimited and in which there are very few available data on basic strength characteristics. The purpose of this paper is to discuss some of the many advantages of this plastic-bonded plywood and to compile some of the pertinent basic strength characteristics.

The strength-to-weight ratio of wood has long been a talking point of engineers interested in wooden construction. Wood by itself had numerous disadvantages which limited its application and helped cause the trend toward complete aluminum structures. Wood alone has a low resistance to splitting along the grain, a low tensile and compressive strength across grain, a rather low shearing strength and an affinity for moisture. These disadvantages had to be overcome to a large degree before wood could again compete with the low density metal alloys. Plywood appeared to be the answer to most of the problems, but plywood by itself could not be forced into compound curvatures or very sharp single curvatures in one direction without setting up initial internal stresses which made it unreliable. This led to the development of the so-called bag-molding process as used today.

In this process, thin veneers are placed either in an inside or outside mold having the contour desired and a rubber blanket is placed over the entire lay-up and clamped around the edges. The mold is then placed in a tank and heat and pressure are applied. Usually this heat and pressure are obtained by steam, which forces the blanket down upon the veneers and distributes the pressure evenly over the entire surface. The temperature and time required in this tank are dependent upon the cycle of the glue used and the thickness of the panel. By use of these thin veneers the internal stresses introduced are negligible. The part, upon removal from the tank, then usually requires only a simple finishing operation and the assembly of attaching fittings.

The glue used in this process is either in the form of thin sheets or a liquid glue spread on the veneers. The use of resin film, which is of the sheet type, has been found to be very satisfactory since the amount of glue may be more easily controlled. This controlled glue line is quite important if panels are to be spliced together, for if there is too deep a penetration of the glue into these thin veneers a problem of getting a bond on scarfed joints arises.

The glues used fall into two main categories: either thermosetting or thermoplastic. Thermosetting glue is glue which experiences a chemical change under heat in which water is

* This paper was presented at a joint meeting of the Aviation and Rubber and Plastics Subdivisions of the American Society of Mechanical Engineers in Cleveland on June 8, 1942, and is published here by permission of that Society.

† Chief of Stress and Structural Research, Duramold Aircraft Corp.

given off. It may be compared, for analogy, to cement in that once it is set by the elimination of this water it can never be made liquid again, even under boiling conditions. Thermoplastic glues, on the other hand, experience no chemical change but rather jell upon setting and can be transformed again to their original state by heat. They might well be likened to butter or wax.

In the construction of plywood by the bag-molding process, it was soon found that a balanced construction was necessary because of the different characteristics across and along grain directions. By a balanced construction is meant that veneers be symmetrically located in respect to thickness, grain direction and species about the center-line of the panel. If this procedure is not followed, warping of the panel will be evident immediately upon removal from the tank. By the use of thin veneers and careful lay-up, a panel that is practically isotropic may be developed. This lay-up causes a decrease in allowable tensile and compressive values from the plain wood when forces are parallel to the grain but increases greatly the shear allowables of the panel. In practice, since there is usually a predominating stress occurring at a certain section, the veneers can be arranged in the most desirable manner to accommodate this stress.

Taking for illustration the design of a monocoque wing, it can be demonstrated how easily adaptable a plywood construction is. By careful design of veneer construction, it is possible to have highly predominating grain direction on the top and bottom skins where the tension and compression stresses due to bending are the major consideration. Then as we move along the contour and more nearly approach the neutral axis, longitudinal or spanwise grained veneers can be tapered out until a lay-up of approximately as many spanwise as chordwise grained veneers exist. At this point, the tension and compression stresses are at a minimum and the shear stress is the design criterion. Thus by careful designing this anisotropic material can be made to work very efficiently.

Moisture content of woods used in plywood construction

An important correction that must be made in all computations for allowable strengths of wood members is that of moisture content. As a piece of wood becomes drier the majority of its strength characteristics are increased rapidly.

TABLE I.—BASIC STRENGTHS OF SIX AIRCRAFT WOODS[1]
(Based on 12% moisture content)

Wood species	Properties parallel to grain: Modulus of elasticity	Properties parallel to grain: Tensile strength	Properties parallel to grain: Compressive strength	Properties perpendicular to grain: Modulus of elasticity	Properties perpendicular to grain: Tensile strength	Properties perpendicular to grain: Compressive strength
	p.s.i.	*p.s.i.*	*p.s.i.*	*p.s.i.*	*p.s.i.*	*p.s.i.*
Birch	2,180,000	16,600	8,170	106,500	810	399
Spruce	1,367,000	10,200	5,610	51,400	384	211
Red gum	1,535,000	11,900	5,800	56,900	442	215
Basswood	1,460,000	8,700	4,730	36,800	276	150
Yellow poplar	1,511,000	9,200	5,290	54,600	333	191
African mahogany	1,335,000	10,700	5,670	101,600	855	432

[1] The values of modulus of elasticity were calculated by means of the formula evolved in this paper and from values of three-ply panels from Table 2:2 ANC-5.[3]
The values of tensile and compressive strengths parallel to the grain are taken from Table I of ref. [2] for the first five species. The values for African mahogany are from ref.[3]
The values of tensile and compressive strengths perpendicular to the grain were determined by multiplying the values for the strengths parallel to the grain by the ratios of E_T/E_L.

The obvious conclusion is to use very dry woods and to put a protective coating on the surface in order to keep this moisture content as low as possible. However, experience has shown that the proportional limit increases at a greater rate than does the modulus of rupture or the modulus of elasticity. The material seems to lose ductility in a dried-out condition and there is a very limited plastic-flow range before failure takes place. It is evident that local concentrations of stresses in a dry material offer a much more difficult problem. From a standpoint of gluing, if the moisture content is too low a starved glue joint is likely to occur. It was determined[1] that a moisture content of approximately 7 to 9 percent was the most efficient in affording a good bond between the veneers. If the moisture content of the wood is quite high, a longer time is necessary in the tank operation. This may result in a boiling out of moisture from the cellular structure of the wood with a consequent low ductility and brittle material. This is not a question of tensile strength since it has been shown in tests

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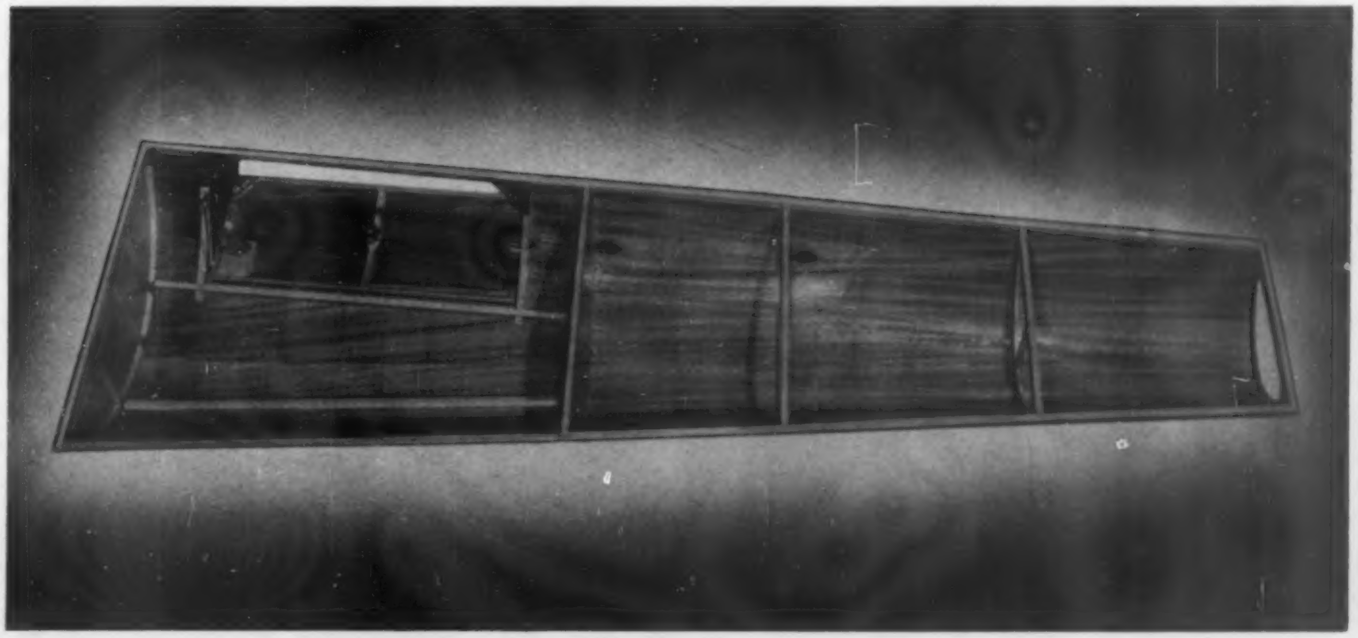


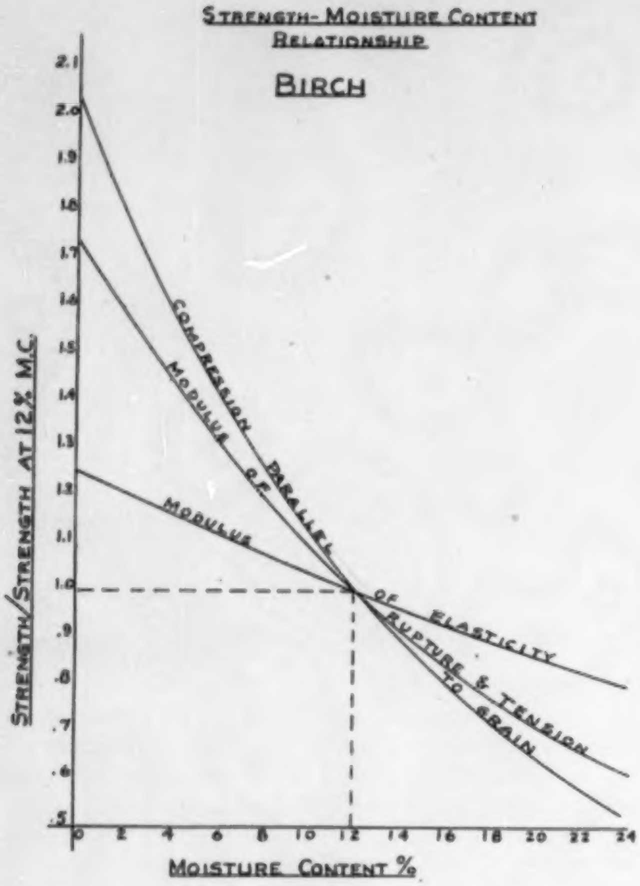


Fig. 3

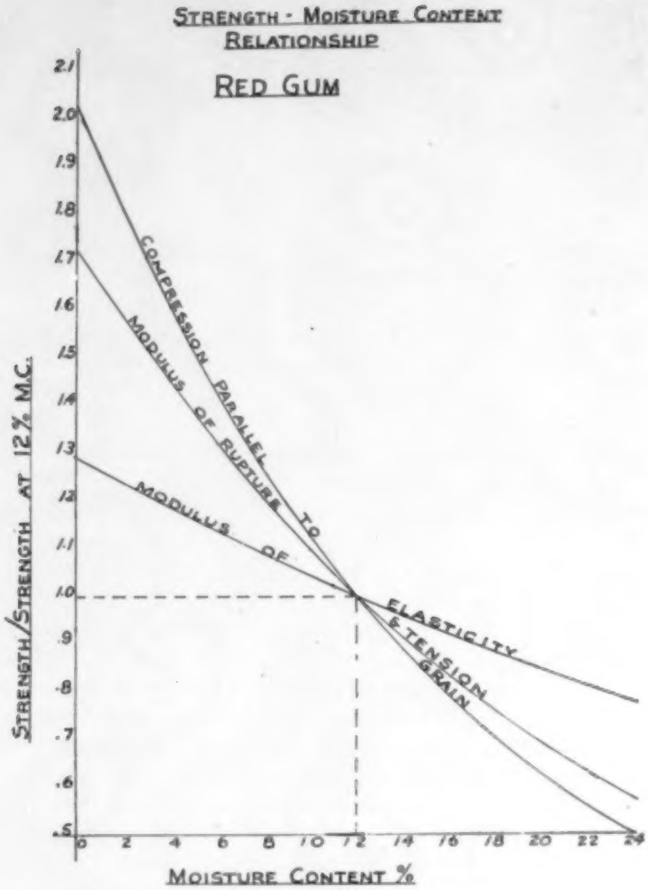


Fig. 5

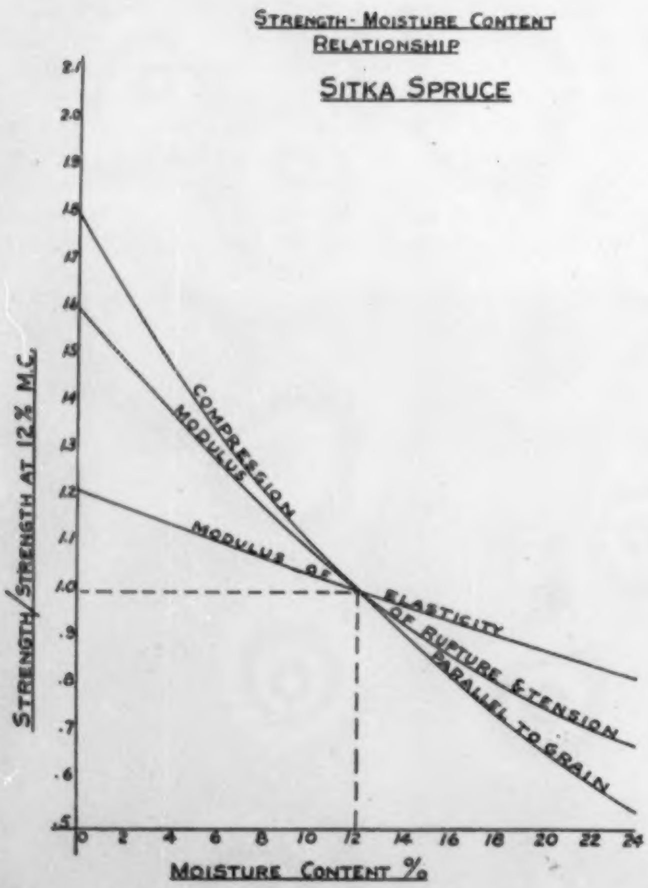


Fig. 4

made on European woods by Gerngross at the Technical University of Berlin[1] that the effect of heating to 284° F. for varying periods of time had little effect on the tensile strength.

There have been numerous articles written on determination of strength characteristics for different moisture contents. In a bulletin published by the U. S. Dept. of Agriculture[2] an equation is developed which affords a fairly accurate means of estimating strength characteristics for a desired moisture content from values obtained for two other moisture contents. The formula as given is:

$$\log S_D = \log S_C + (C - D)\,\frac{\log (S_B \div S_A)}{A - B} \qquad (1)$$

where A, B, C and D are percentages of moisture content, S_A, S_B, S_C, S_D are corresponding strength values, S_A and S_B being known strength values for moisture contents A and B from tests. S_C equals either S_A or S_B and C equals the corresponding value of A or B.

Using this relationship and values of A, B, S_A and S_B from Table I of the same reference, the author has here plotted the strength-moisture content curves for five woods commonly used in the aircraft industry, namely: birch, spruce, red gum, basswood and yellow poplar. These resulting curves for modulus of elasticity, modulus of rupture, and

[1] Perry and Bretl, "Hot Pressing Technique for Plywood," Trans. A.S.M.E., Vol. 60, pages 682–685, January 1938, November 1938.
[2] "Strength and Related Properties of Woods Grown in the United States," Technical Bull. No. 479, U. S. Dept. of Agriculture.
[3] Heck, Geo. E., "Average Strength and Related Properties of Five Foreign Woods," Tech. Note No. 563, U. S. Dept. of Agriculture.
[4] Gassner, A. A., "Resin-bonded Wood Laminates for Shell Type Aircraft Construction," Journ. Aero. Sciences, March 1942.
[5] "Strength of Aircraft Elements," ANC-5, issued by the Army-Navy-Civil Committee on Aircraft Requirements, 1940.

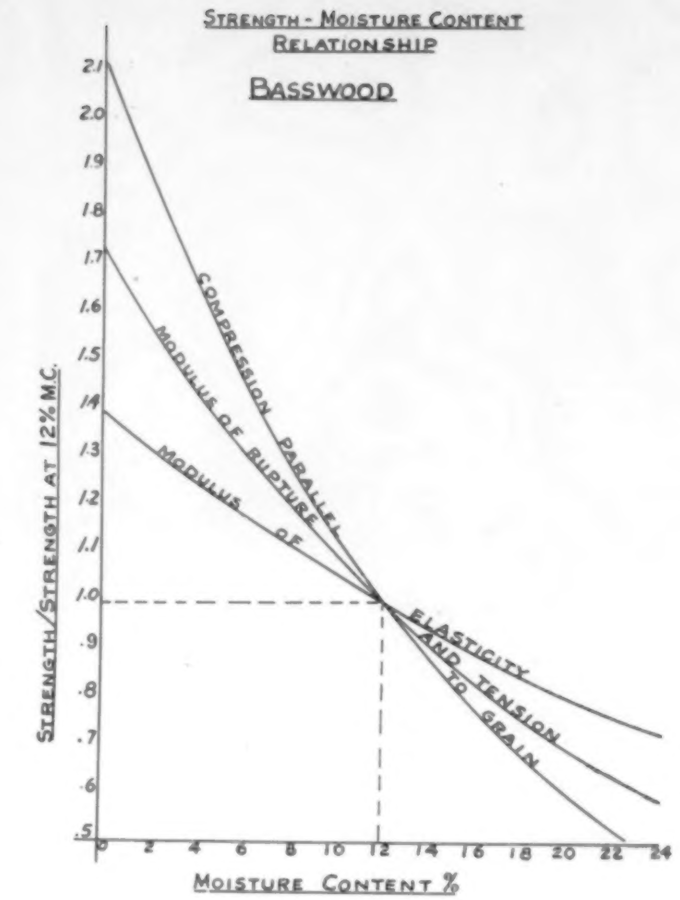


Fig. 6

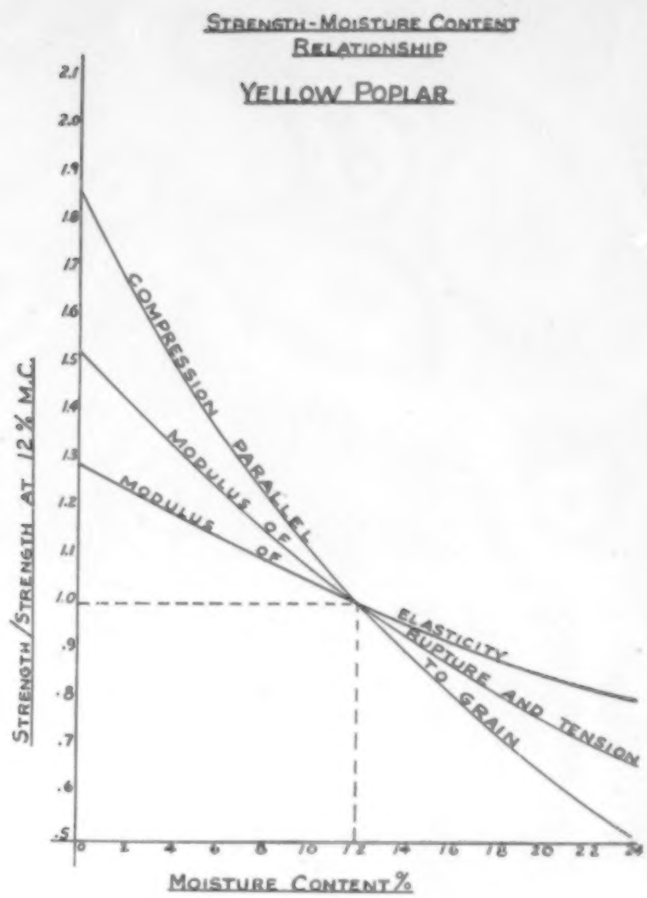


Fig. 7

compression parallel to the grain are given in Figs. 3 to 7. The values for African mahogany as plotted in Fig. 8 were obtained from a paper by George E. Heck.[3] These graphs are plotted with 12 percent moisture content as unity since this is more or less the standard adopted. To correct to 12 percent moisture any specimen with known moisture content, it is necessary only to divide the value obtained at the known moisture content by the value read from the curve corresponding to the strength characteristic in question.

Modulus of elasticity of plywood panels

One of the first things an engineer must know about a substance is its modulus of elasticity. In this regard wood presents a little more difficult problem, since each species has a different value parallel and perpendicular to grain direction. Therefore some means must be found to calculate the modulus of elasticity for any construction of plies and species. There have been few data published on the modulus of elasticity across the grain of wood. Gassner,[4] however, in a paper presented before the Institute of Aeronautical Sciences, offers an ingenious means of working backwards from test data on three-ply panels to determine from these data the apparent modulus of the single veneer. Data published in Table 2:2 of ANC-5[5] give values for column bending moduli of three-ply panels determined from column bending tests on three-ply panels having veneer thickness equal and using the same species throughout. In order to determine the apparent moduli for the single veneers, an analysis must first be made of the stress distribution across a plywood panel subjected to bending loads. For a homogeneous material the distribution is well known and

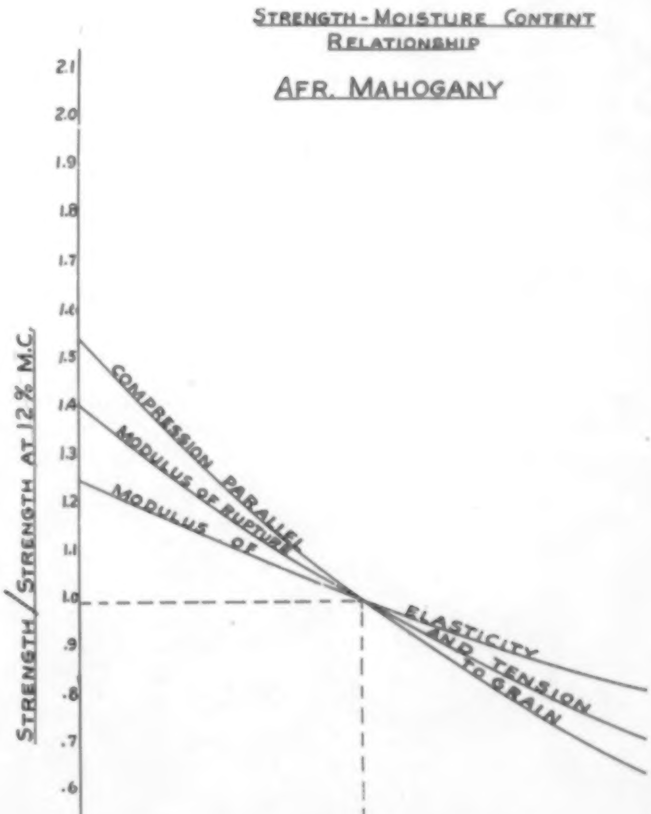


Fig. 8

the stress at any point according to the beam theory is given by the formula

$$f = \frac{MC}{I} \tag{2}$$

where

f = stress at any point
M = moment at the section in question
C = distance of the fiber from the neutral axis of the section
I = moment of inertia of the entire section

This relationship is based on the assumption of the beam theory that plane sections remain plane after bending and that the material obeys Hooke's law. It immediately follows that the stress distribution across a plywood panel where the modulus of elasticity of the separate veneers changes is not in the form of a straight line. Since the strain must vary linearly with distance from the neutral axis, it is evident that the stress at any point is dependent upon the modulus of elasticity of the veneer in question.

Letting

E_V = modulus of elasticity of veneer in question
E_{PI} = apparent flexural modulus of elasticity of the entire panel
Δ_V = strain of specific veneer
Δ_P = strain of extreme fiber of panel
I_V = moment of inertia of veneer about neutral axis of cross section of panel
I_P = moment of inertia of entire panel about neutral axis of cross section of panel
f_V = stress in veneer in question
C = distance of veneer from neutral axis of panel
r = radius of curvature of panel when subjected to bending moment
dA = infinitesimal area at point in question
M_V = moment carried by veneer in question
M_P = total moment on panel

it follows from Hooke's law that

$$f_V = E_V \Delta_V \tag{4}$$

It can be shown that

$$\Delta_V = \frac{C}{r} \tag{5}$$

(See any text on strength of materials.) This force is balanced by an equal and opposite force at the same distance on the other side of the neutral axis.

$$\text{Force acting} = \frac{E_V C\, dA}{r} \tag{6}$$

$$M_V = \frac{E_V C\, dA\, C}{r} \tag{7}$$

But since the sum of the internal moments must equal the external moment applied, then

$$\Sigma M_V = M_P \tag{8}$$

$$M_P = \int \frac{E_V C^2 d A}{r} \tag{9}$$

and

$$\frac{I}{r} = \frac{M_P}{\int E_V C^2\, dA} = \frac{M_P}{E_{PI}\, I_P} \tag{10}$$

From equation (10) it immediately follows that

$$E_{PI} = \frac{\Sigma E_V I_V}{I_P} \tag{11}$$

Substituting $f_V = \dfrac{E_V C}{r}$ in equation (10), the stress at any point in a plywood panel is equal to

$$f_V = \frac{M_P C}{I_P} \frac{E_V}{E_{PI}} \tag{12}$$

Now for a three-ply panel, let

E_f = modulus of elasticity of face veneer
E_c = modulus of elasticity of core veneer
E_{PI} = modulus of elasticity of panel
I_f = moment of inertia of face veneer about neutral axis of panel
I_c = moment of inertia of core veneer about neutral axis of panel
I_p = moment of inertia of panel about neutral axis
t = thickness of panel

If all veneers are of the same thickness

$$I_p = \frac{t^3}{12}; \quad I_c = \frac{t^3}{3^3}/12$$

and

$$2I_f = I_p - I_c = t^3/12 - t^3/324$$

Therefore

$$E\left(\frac{t^3}{12} - \frac{t^3}{324}\right) + E_c\left(\frac{t^3}{324}\right) = E_{PI}\frac{t^3}{12} \tag{13}$$

dividing both sides by $t^3/12$

$$.963\, E_f + .037\, E_c = E_{PI} \tag{14}$$

Obtaining from ANC-5[5] values of E_{PI} for three-ply panels having grain direction of face veneers both parallel and perpendicular to the loading, simultaneous equations may be set up and solved yielding the moduli of elasticity for the separate veneers. These values have been obtained and are given in Table I corrected for 12 percent moisture content. These values should be checked for accuracy from values obtained from multi-ply panels.

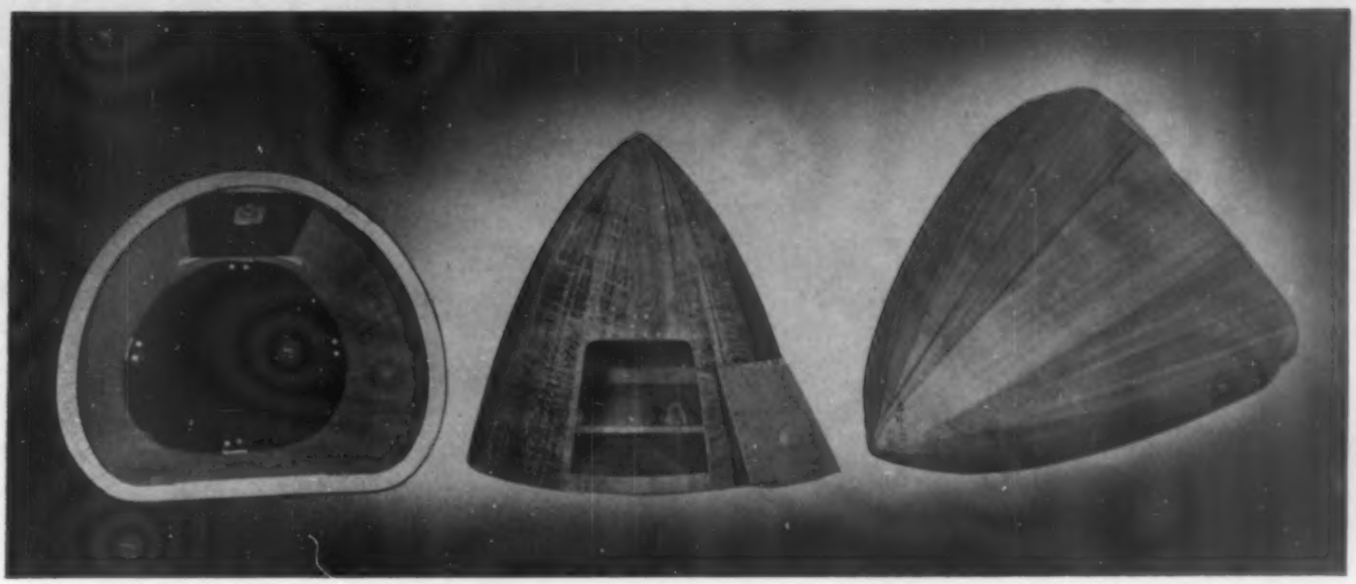
Having the modulus of elasticity of each veneer in a composite panel the determination of the apparent modulus for bending characteristics can readily be made.

When a member composed of different materials is subjected to an axial load, the strain in the panel must of necessity equal the strain in each component part. Also the total force required to strain the panel to this position must be equal to the total of the forces in the component parts. Considering for simplicity a three-ply panel composed of the same species veneers, it can readily be shown that

$$E_P\, \Delta_P t_p = t_f E_f \Delta_f + t_c E_c \Delta_c \tag{15}$$

where

E_P = modulus of elasticity of the panel
Δ_f = strain of the face veneers
Δ_c = strain of the core veneer
t_f = total thickness of face veneers
t_c = thickness of core veneer
t_p = thickness of panel



9—*Solid construction of a complex, plastic-plywood shape indicates the potentialities of parts made by this method*

But since $\Delta_P = \Delta_f = \Delta_c$

$$E_P = \frac{t_f}{t_p} E_f + \frac{t_c}{t_p} E_c \qquad (16)$$

It has thus been shown that when using a material of this type care must be exercised in choosing the correct modulus for the loading applied.

Tensile and compressive strengths of plywood panels

Employing the same obvious reasoning that the strain of each veneer in a panel must be equal to the strain of the panel, and assuming elastic properties of veneers up to failure, a method of least work may be applied to a panel to determine tensile and compressive stresses for the separate veneers.

Assuming first that all veneers in the panel are of the same species, let

Δ_L = strain of veneers with grain longitudinal or in direction of applied load

Δ_T = strain of veneers with grain transverse or perpendicular to direction of load

f_P = apparent stress in panel

f_L = stress in longitudinal veneers

f_T = stress in transverse veneers

t_L = total thickness of longitudinal veneers

t_T = total thickness of transverse veneers

t_P = total thickness of panel

E_L = modulus of elasticity of longitudinal veneers

E_T = modulus of elasticity of transverse veneers

Then

$$f_P t_P = f_L t_L + f_T t_T \qquad (17)$$

but

$$f_L = \Delta_L E_L \text{ and } f_T = \Delta_T E_T$$

Solving for a relationship between f_L and f_T since $\Delta_L = \Delta_T$

$$\frac{f_L}{f_T} = \frac{E_L}{E_T}$$

therefore

$$f_P t_P = f_L t_L + f_L \frac{E_T}{E_L} t_T \qquad (18)$$

For simplification, if X = the percentage of longitudinal veneers and Y = the percentage of transverse veneers

$$100 f_P = X f_L + Y \frac{E_T}{E_L} f_L \qquad (19)$$

It can safely be assumed then that the longitudinal veneers fail first and, therefore, using the modulus of rupture (considered as a measure of the tensile strength) and the maximum crushing strength of the longitudinal veneers, the tensile and compressive strengths for a panel may be calculated. These are given for six woods in Table I. The assumption that elastic qualities hold up to failure should not cause too great an error since the elastic limit of wood is quite close to the ultimate. Also the ratio of E_L/E_T appears to be greater than the ratio of modulus of rupture longitudinally to modulus of rupture transversely.

If a panel is so constructed that the longitudinal veneers are of different species, the strength of the panel is evidently dependent upon the species which has the least elongation at failure and the allowable strength of the stronger veneer must be reduced so that $f_L = (E_L/E_L{}^1) f_L{}^1$.

Poisson's ratio for a multi-ply panel

Very few data have been published on the value of Poisson's ratio for various species of wood. In a paper by C. F. Jenkins[8] these values are given for four species of wood. Knowing these basic values, Poisson's ratio for a complete panel may be calculated.

Let

μ_L = Poisson's ratio for veneers having longitudinal grain in direction of loading

μ_T = Poisson's ratio for veneers having transverse grain in direction of loading

μ_P = Poisson's ratio for entire panel in direction of loading

E_{PP} = modulus of elasticity of panel for axial load in direction of loading

E_{PT} = modulus of elasticity of panel for axial load perpendicular to direction of loading

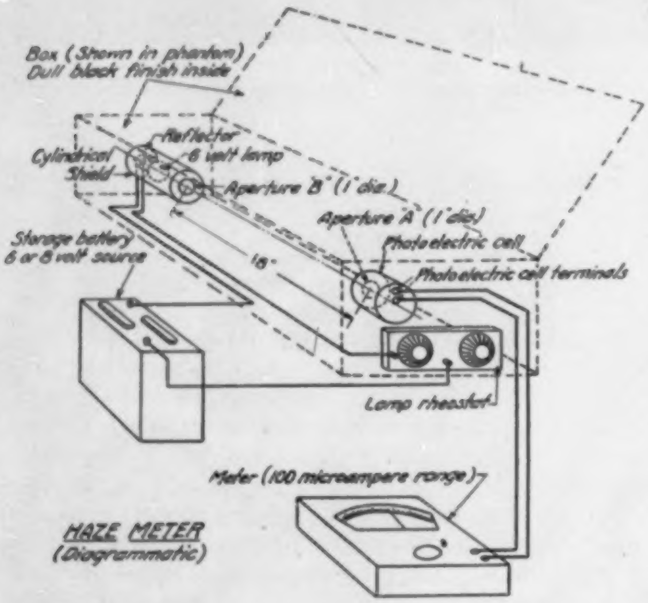
(*Please turn to page 110*)

[8] Jenkins, C. F., "Materials of Construction Used in Aircraft," Aeronautical Research Committee (British) Report, 1920.

Measuring haze of transparent plastics*

Scope

1. This method of test is designed to measure photoelectrically the haze of transparent plastics, using specimens with substantially plane, parallel faces. It is not recommended for the measurement of low ranges of scattering (less than 1 percent) nor is it intended for use in evaluating translucent plastics. This method provides a rapid and readily available means of obtaining quantitative values for haze arising from internal nonhomogenous particles, surface scratches, and other imperfections.



1—*Haze meter, showing apparatus and connections*

Definition

2. *Haze.* Haze is that fraction of the total transmitted light from a normally incident beam which is not transmitted in a straight line, and is calculated as follows:

$$\text{Haze, percent} = \frac{T - T_r}{T \times 100} = \frac{T_d}{T} \times 100$$

where:

T = total light transmitted,
T_r = amount of light transmitted in a straight line, and
T_d = amount of light transmitted in all directions but rectilinearly.

NOTE. Measurements of haze shall be equivalent to those that would be obtained by the I.C.I. standard observer and I.C.I. standard illuminant A.

Apparatus

3. The apparatus shall consist of a haze meter as illustrated in Fig. 1. The light source shall consist of a 6-v. automobile-type bulb mounted in front of a reflector. The light source shall be placed within a cylindrical shield that is blackened on the inside. The end of the cylindrical shield opposite the reflector shall be closed and equipped with a circular aperture, 1 in. in diameter. A circular, blackened disk containing a similar aperture 1 in. in diameter shall be mounted directly in front of a photoelectric cell 18 in. from the first aperture. The photoelectric cell shall be the Weston photronic cell, type I or III with Viscor filter, or its equivalent. The cell shall be connected to an ammeter with a 100-microamp. range and an internal resistance of 50 ohms. If a dark room is not available, the light source unit and the photoelectric cell unit may be mounted in a suitable box finished on the inside in dull black to reduce reflection to a minimum. The lid of the box, finished in dull black on the inside, shall fit tightly to prevent any external light from reaching the photoelectric cell. A 6- or 8-v. storage battery shall be used to operate the lamp. The intensity of the lamp shall be adjustable by means of a rheostat.

Test specimens

4. The test specimens shall be sufficiently large to cover completely the 1-in. apertures of the haze meter. They may be cut from plastic sheets or molded pieces or they may be prepared from a plastic in the customary manner peculiar to the physical properties of the particular material to be tested (by compression molding, injection molding, laminating, casting, etc.). The surfaces of the test specimens shall be substantially flat and parallel. The thickness of the test specimen shall be as received or for comparative purposes shall be 0.125 ± 0.005 in. Care shall be taken to remove dust and grease from the specimens prior to measurement.

Procedure

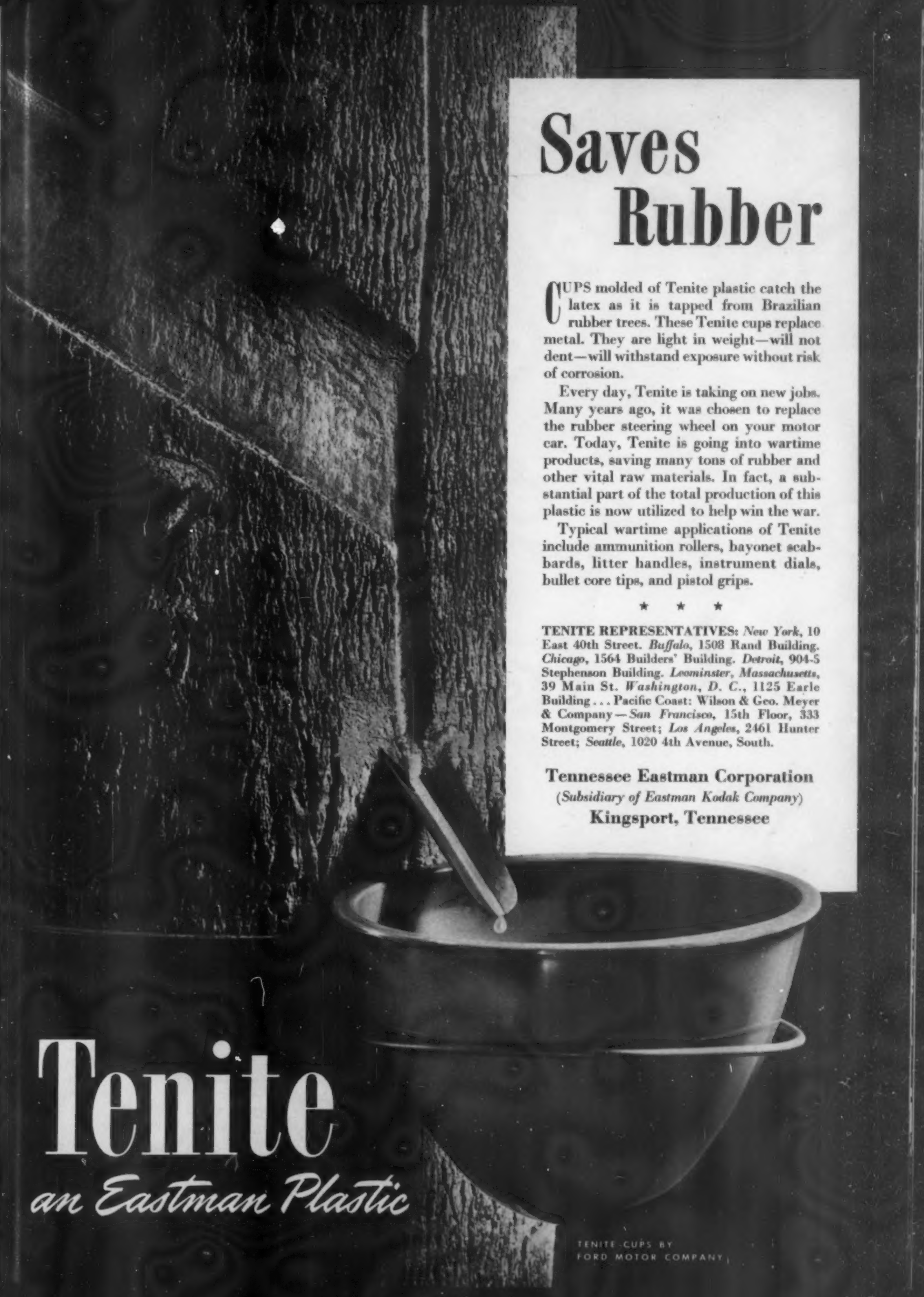
5. (*a*) At least three measurements of light transmission and haze shall be made and averaged for each test specimen. The lid of the box containing the light source and photoelectric cell shall be closed during the test unless the measurements are made in a dark room. The intensity of the light shall be adjusted so that a current of 100 microamp. is obtained from the photoelectric cell. The specimen shall then be placed in front of aperture A, Fig. 1 at the photoelectric cell, and the microammeter shall be read (Note 1).

NOTE 1. Of the light incident on the specimen, a fraction is transmitted undeviated and a fraction is scattered by the surfaces and the interior of the specimen. The photoelectric cell receives the undeviated fraction of the light and that part of the scattered light that is not deflected at angles greater than about 90°. The light transmission of the specimen is the fraction of the original light received by the photoelectric cell that continues to reach the sensitive element of the cell when the specimen is placed over aperture A. A reading of the microammeter taken with the specimen at aperture A gives the percentage light transmission directly when the initial reading of the microammeter is 100 microamp.

(*b*) The specimen shall then be placed in front of aperture B, Fig. 1, 18 in. distant from aperture A, and just in front of the cylindrical shield covering the light source. The microammeter shall be read again (Note 2).

(*Please turn to page 136*)

* This tentative method of test for Measuring Photoelectrically the Haze of Transparent Plastics, A.S.T.M. designation D672–42T, is published here by permission of the American Society for Testing Materials.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General

EFFECT OF WAR DEVELOPMENT ON POST-WAR DESIGN. Frank Jardine. S.A.E. Journal *50*, 299–303 (July 1942). The plastics industry has expanded greatly both in fabrication and production of its many different materials. These materials in many forms will be available for new uses in the postwar car. Many of our interior decorations, which to date have been metal, will become plastics—window molding, interior door moldings, instrument panel parts, etc. Some consideration will be given to plastic body parts and possibly doors, but not for early postwar production. Some designers will try plastic windows sealed in flush with the outside of the car for better streamlining and lighter, less expensive construction. Sealed-in windows will require either air-conditioning or filtered air. Double plastic windows could be used with an air space between to eliminate defrosting troubles. Plastics will predominate, says one automotive engineer.

ORDNANCE DEPARTMENT PLASTIC AND PAINT DEVELOPMENTS. E. T. McBride. Chem. and Eng. News *20*, 849–51 (July 10, 1942). The plastic components used by the Small Arms, Artillery, Ammunition, and Tank and Combat Vehicle Divisions are explained with respect to service usage, storage and the types of materials found to be satisfactory for each. In the paint program, conservation of resins, pigments, oils and solvents has been given prime consideration. Specially treated castor or linseed oil may provide a satisfactory substitute for china wood oil. A clear phenol-formaldehyde resin varnish has been found suitable for coating the inside of steel cartridge cases. (See MODERN PLASTICS, April 1942, pages 39–41.)

TESTING WINDOW GLASS FOR CONCUSSION DAMAGE. Eng. News-Record *128*, 521 (Apr. 2, 1942). Engineers of the San Francisco building department have been conducting tests on window glass to which tapes and lacquers have been applied. A swinging bag of shot was used to produce the impact. Particular attention has been paid to flying glass particles. Although these methods of treatment render a considerable measure of protection, it seems necessary to use a more positive means to really safeguard pupils in school rooms. It is suggested that in school buildings a 1/2-inch mesh metal screen be fastened to the inside of the sash and that this be supplemented by a heavy quilted curtain (similar to a mattress pad). The screen would remain in place permanently and the pad would be rolled into place only during an air raid. The cost of the screen and curtain is estimated at 40 cents per square foot.

Materials

PLASTICS FROM AGRICULTURAL MATERIALS. O. R. Sweeney and L. K. Arnold. Iowa Engineering Exp. Sta. Bulletin No. 154 (1942). This bulletin deals with plastics utilizing corncobs, oat hulls, cornstalks, furfural and soybean meal. Four plastic products which appeared to have commercial possibilities were studied. A dark brown resin was produced by heating together extracted soybean meal, furfural, phenol and ammonium hydroxide. A thermoplastic molding material was made by heating together corncobs, cresol and sulfuric acid. Addition of furfural, hexamethylenetetramine and filler converted this resin to a thermosetting material. A fourth plastic was produced by mixing acid-hydrolyzed cornstalks and oat hulls with chemicals, such as aniline, furfural and fillers. (See MODERN PLASTICS, December 1941, pages 70, 72, 90, 92.)

CLOTH LAMINATES FOR NON-STRUCTURAL PARTS. John Delmonte. Aero Digest *41*, 247–8 (July 1942). The preparation of low-pressure laminates is discussed. The selection of the fabric and plastic and the properties of the finished laminates are considered. Their applications for non-structural parts on aircraft are briefly reviewed.

Applications

IDENTIFICATION TAGS MADE OF PLASTIC. B. Levy. Elec. World *117*, 1696, 2078 (May 16, June 13, 1942). The use of laminated plastic material made with phenolic or vinyl resins for identification tags is described. Figures and designs are routed into an opaque surface, exposing a contrasting core. Signs exposed since June 1937 proved durable.

SIMPLE ULTRACENTRIFUGE WITH PLASTIC ROTOR. K. G. Stern. Science *95*, 561–2 (May 29, 1942). The construction of an air-turbine ultracentrifuge with a methyl methacrylate resin rotor is described. The plastic rotor is 0.5 in. thick and 6 in. in diameter. The use of the plastic results in a simplification of design. The top speed attained has been 17,400 r.p.m. at 48 lb. per sq. in. air pressure. This gives a force of 20,200 times gravity at the center of the analytical fluid cell which is 6 cm. from the center of rotation. A speed of 57,000 r.p.m. was obtained with a 2-in. diameter rotor with 80 lb. per sq. in. air pressure.

HOW TO USE LAMINATED PLASTIC BEARINGS. V. E. Enz. Power *86*, 405–6 (June 1942). Plastic bearings have been successfully applied in steel mills, rubber-mill line drives, cement mills, deepwell pumps, water-wheel guide bearings, rod mills and on ships. Numerous other applications are being worked out where phenolic laminated bearings will replace tin-base babbitt, bronze, lignum vitae, wood and rubber.

THE USES OF PLYWOOD IN AIRCRAFT. T. D. Perry. Aero Digest *41*, 200, 205–6 (July 1942). The successful plane of the future will combine metal, plywood, fabric and other materials, each used in the manner to take advantage of its most useful qualities. The outstanding characteristics of aircraft resin-bonded plywood are reviewed, production methods are described and applications in structures, propellers and accessories are considered.

Coatings

AN EVALUATION OF METHOCEL AS A PIGMENT ADHESIVE FOR PAPER COATINGS. R. M. Upright, M. Kin and F. C. Peterson. Paper Trade J. *114*, 36–40 (1942). Pigment-coating slips were prepared from clay, satin white, titanium dioxide, and a 75–25 clay-calcium carbonate mixture. Methylcellulose and casein, respectively, were used as the adhesive in amounts ranging from 12 to 28 percent of the weight of the coating pigment. The coated and calendered sheets were evaluated for pigment bonding strength, ink receptivity, smoothness, opacity, gloss, brightness, flexibility and printability. As compared with casein, methylcellulose exhibits a higher binding strength and a greater resistance to ink penetration, produces a more flexible coating, and effects a reduction in gloss, opacity, and to a slight extent in brightness. There appeared to be no appreciable difference in smoothness.

ACCELERATED TESTING OF PAINT COATINGS. H. G. Arlt. A.S.T.M. Bulletin *1942*, 9–17 (May). The results of a questionnaire survey of producers and users of paint products are tabulated. The majority of testers believe that the commercial weathering machines or cycles now in use are unsatisfactory for accurately evaluating durability of paint coatings, but that accelerated weathering tests have sufficient promise to warrant continuing with their development and standardization.


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Technical briefs

Abstracts of articles on plastics in the world's scientific and engineering literature relating o properties and testing methods, or indicating significant trends and developments

Engineering

COMPOSITION CORK. L. P. Hart, Jr., R. W. Work, L. T. Irish and M. A. Howe. Ind. Eng. Chem. *34*, 649–58 (June 1942). Composition cork has been widely and increasingly used in many other industries since its development about 1900, but in few cases does it need to possess such long life or be of such quality and uniformity as in its application in the electrical field. This industry depends almost entirely on resin-bonded composition cork rather than on the more common protein-bonded type. Both of them are manufactured in a similar manner, and each consists essentially of granulated cork, a plasticizer such as glycerol or glycol and an adhesive, which have been mixed before being molded and baked. A method of quality control is proposed, based on statistical analysis of the material. A plan is suggested for a quantitative determination of the quality standard of each vendor. A list of patents and literature pertaining to composition cork is appended.

PROPERTIES AND CHARACTERISTICS OF FORMEX WIRE. J. J. Curtin. Gen. Elec. R. *45*, 285–92 (May 1942). The properties and characteristics of Formex wire, wire which is insulated with a plastic film of the polyvinyl acetal type, are described. The properties considered are dielectric strength, abrasion resistance, flexibility or extensibility, adhesion, solvent resistance, thermoplastic flow, resistance to heat shock, compression resistance, power factor, winding-space factor, moisture resistance and shelf aging. A comparison with enameled wire is made. The methods of testing are described.

VINSOL RESIN—A NEW SOIL STABILIZER. Eng. News *128*, 777–81 (May 7, 1942). Small amounts of Vinsol resin added to certain soils make it possible to convert these soils into a firm base for road construction. The methods of treatment, the types of soil which may be treated successfully and some applications are described. It is pointed out that although the Vinsol treatment is beneficial in many cases, it is not a cure-all for soil stabilization. The limitations of the treatment are discussed.

Chemistry

CHEMICAL STRUCTURE OF PLASTICS. C. A. Redfarn. Brit. Plastics *14*, 6–21 (June 1942). A review. Plastics are considered to fall into three classes with respect to polymer building: 1) Polymerized compounds of small chain length, e.g., phenol-formaldehyde, urea-formaldehyde and the ethenoids; 2) modifications of naturally occurring polymers, e.g., cellulose and casein; and 3) polymerizing relatively large monomers, e.g., diamine diacid supercondensation products (nylon), so that for a given number of chemical links much larger molecules are produced than with class 1).

RESILIENCE AND DOUBLE REFRACTION WITH ROLLED POLYSTYRENE. E. Jenckel and F. Nagel. Kolloid Zeit *97*, 37–46 (Oct. 1941). The effects of rolling temperature and heat treatment on the double refraction and on the deformation of thin polystyrene films were measured. The decrease of double refraction and of contraction as functions of time show a similar trend. But at certain temperatures there was a period of expansion following the rapid contraction. This is explained by a model consisting of three or more piston-spring arrangements in parallel, as used by Maxwell for describing the behavior of elasto-viscous substances. Based on this model a tentative explanation is given for the changes in double refraction and contraction as caused by structural changes in the molecular chain, e.g., the turning of phenyl-rings around their links with the polyvinyl chain.

Testing

NEW METHODS FOR MECHANICAL TESTING OF PLASTICS. L. H. Callendar. Brit. Plastics *13*, 445–58, 506–19 (Apr., May, 1942). Methods for determining impact strength and plastic yield temperatures are discussed. "Shearing and tearing" and "Broken-half" errors are shown to be very large for some plastics. Detailed experimental results are reported in support of a method of impact testing bound up with the following factors: 1) Use of the same radius of notch, 0.5 mm., and same depth of notch, one-third the thickness, on test pieces of any cross section; 2) Charpy anvils adjusted to a distance apart equal to 6 times the thickness of the test piece; 3) minimum velocity of impact of 8 ft. per sec.; 4) end-point of the test taken as the first definite crack or break; 5) use of a guillotine or vertical drop-weight type of machine. A recommended design of machine is shown in photographs. The importance of controlled temperature and humidity in impact testing of plastics is emphasized.

DETERMINATION OF THE DRYING RATES OF THIN FILMS. G. Rieger and C. S. Grove, Jr. Ind. Eng. Chem., Anal. Ed. *14*, 326 (Apr. 1942). A new technique for determining the drying rates of thin films is described. The films were cast on microscope slides and the loss in weight determined on an analytical balance which had a scale attached to the pointer. An image of the scale was projected on a screen. The technique can be used to study rapidly drying films and to save time in studying slowly drying films. Reproducibility of results is good. The method was applied to 0.25, 0.5, 4, 20 and 70 sec. cellulose nitrate dispersed in ethyl acetate, ethyl acetate and toluene, and ethyl acetate and butyl alcohol.

Properties

THE VELOCITY OF SOUND IN METHYL METHACRYLATE POLYMER. Louis R. Weber and Frank P. Goeder. Phys. Rev. *61*, 94–5 (1942). The velocity of sound in methyl methacrylate polymer was found to be: (a) 2070 m./sec. by electrostatic excitation; (b) 2090 m./sec. by Kundt's tube; and (c) 1600 m./sec. from Young's modulus. The differences are attributed to cold flow at high stresses.

VOLUMETRIC EXPANSION OF PLASTICS. M. A. Azam. British Plastics *13*, 404–5 (Mar. 1942). The coefficient of volume thermal expansion for polystyrene was found to be 3.44×10^{-4} for the temperature range 185 deg. to 80 deg. F.; that of polyvinyl chloride-acetate was 3.92×10^{-4} for the range 196.5 deg. to 99 deg. F.

HARDNESS OF PLASTIC MATERIALS. Chem. Age *46*, 122 (Mar. 7, 1942). Carborundum falling on a specimen from a given height with the specimen at an angle of 30 deg. to the horizontal was used to determine hardness. The degree of abrasion produced by the particles was measured by a photoelectric haze method. Relative values for the scratch resistance of Perspex, plate glass and "Pyrex" obtained by this method were 20, 115 and 180, respectively.

STRENGTH OF PLASTICS. H. R. Moyer. Prod. Eng. *13*, 379–81 (July 1942). The tensile, compressive, flexural, impact and shear strength of four typical laminated phenolic plastics and four typical molded phenolic plastics are given in graphical form. In addition moduli of elasticity in tension and compression of the laminated materials are given. The thermal effect on tensile, compressive and impact strength for one of the laminated compositions is shown. The strength properties of the laminated materials with respect to grain or direction are given. The laminating materials were fine weave fabric, heavy weave canvas, cotton fibre paper and kraft paper. The molded materials were filled with various grades of chopped fabric.

Ewing Galloway

U. S. Plastics Patents

Copies of these patents are available from the U. S. Patent Office, Washington, D. C., at 10 cents each

MOLDED PLYWOOD. E. L. Vidal and L. J. Marhoefer (to Vidal Research Corp.). U. S. 2,276,004, March 10. Assembling alternate layers of wood veneer and a thermoplastic adhesive, and molding the assembly in a mold enclosed in a flexible bag for applying fluid pressure.

THERMOPLASTIC. Jas. A. Kennedy. U. S. 2,284,432, May 26. Plasticizing sulfur with about 8 percent of aluminum stearate, 20 percent of silica powder, 12 percent of woodflour, 4 percent of sugar and up to 9 percent of rubber.

PLASTIC FILM. H. G. Rogers (to Polaroid Corp.). U. S. 2,284,590, May 26. Apparatus for applying a coating of plastic to a nonplanar surface.

CREASEPROOFING FABRIC. P. C. Schroy (to American Cyanamid Co.). U. S. 2,284,609, May 26. A creaseproofing composition of melamine-formaldehyde resin and N-ethanol stearamide.

CARBAMATE POLYMERS. W. E. Catlin (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,284,637, June 2. Forming linear carbamate polymers by reaction of a diisocyanate or diisothiocyanate with a dihydric alcohol or phenol, or with a dithiol.

ACRYLATE RESINS. L. Coes, Jr. (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,284,639, June 2. Interpolymerizing an acrylate or methacrylate ester with styrene or nitrostyrene and with ethylidene diacrylate or dimethacrylate.

BRAID. Camille Dreyfus. U. S. 2,284,728, June 2. Braiding yarn around a thermoplastic core and bonding the core and sheath together.

CHEWING GUM BASE. F. T. De Angelis (to L. A. Dreyfus Co.). U. S. 2,284,804, June 2. Compounding polybutene resin with another resin and a wax.

CELLULOSIC RESIN. E. Färber (to Polyxor Chemical Co.). U. S. 2,284,860, June 2. Acid condensation of cellulose or a pentosan with an alcohol to form a resin.

POLYMERS. W. E. Hanford and D. F. Holmes (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,284,896, June 2. Reacting di- or polyfunctional isocyanates, isothiocyanates or the like with di- or polyfunctional compounds to form macromolecular polymers.

INTERPOLYAMIDE. M. M. Brubaker, W. E. Hanford and R. H. Wiley (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,285,009, June 2. Forming a linear polymer from 6-aminocaproic acid and the hexamethylenediammonium salts of sebacic, adipic, suberic and azelaic acids in stated proportions.

DRESS FORM. H. H. Straw; S. P. Lovell (to Beckwith Mfg. Co.). U. S. 2,285,064 and 2,285,376, June 2. Forming hot soaped thermoplastic sheets around a model, allowing them to harden, match-marking the panels, stripping them from the model and reassembling them in the marked positions; and following a similar procedure with plastic-impregnated fabric panels on a human model.

HOT MELT COATING. D. A. Rothrock and H. C. Cheetham (to Resinous Products and Chemical Co.). U. S. 2,285,095, June 2. Coating paper with a blend of resinified dihydric dinuclear hydroaromatic alcohol, plasticized ethylcellulose and wax.

HOLLOW ARTICLES. E. T. Ferngren (to Plax Corp.). U. S. 2,285,150, June 2. Utilizing a split neck mold in apparatus for making hollow articles from plastics.

POLYAMIDES. K. Thinius (to Deutsche Celluloidfabrik Akt.). U. S. 2,285,178, June 2. Blending a cellulose ester or ether with a mixed polyamide resin.

PROTEIN RESIN. L. E. Dimond and W. L. Hicks (to Carl Marx). U. S. 2,285,193, June 2. Condensing a degraded protein with a phenol and an aldehyde.

CONTAINERS. J. C. Morrell. U. S. 2,285,219–20, June 2. Making cans with metal ends, and walls of a fibrous base impregnated with a synthetic plastic binder.

THREADED MOLDINGS. A. B. McGinnis (to Wheeler Stamping Co.). U. S. 2,285,297, June 2. Improved apparatus for molding plastics in shapes with screw-threaded parts.

HOLLOW ARTICLES. C. G. Staelin (to Owens-Illinois Glass Co.). U. S. 2,285,370, June 2. An acidified gas is used in spray application of coatings of a thermoplastic the polymerization of which is accelerated by acid.

COUMARONE-INDENE POLYMERS. F. W. Corkery (to Pennsylvania Industrial Chemical Corp.). U. S. 2,285,416–7, June 9. Plasticizing a relatively impenetrable coumarone-indene resin (molecular magnitude 7 or more monomeric units) with a dimer; and adding a high-melting coumarone-indene resin (11 monomeric units or higher) to a blend of dimers with intermediate polymers ranging from trimers to hexamers.

UREA RESIN. G. F. D'Alelio (to General Electric Co.). U. S. 2,285,418, June 9. Condensing urea or a derivative thereof with an aldehyde and chloroacetamide.

VINYL PLASTIC. A. K. Doolittle (to Carbide and Carbon Chemicals Corp.). U. S. 2,285,420, June 9. Plasticizing a vinyl resin with an acetylricinoleate of a glycol (or polyglycol) monoether of an alcohol or of a phenol.

MOLDING COMPOSITION. A. L. Dixon and R. P. Lutz (to Western Electric Co.). U. S. 2,285,501, June 9. Mixing a dry powdered phenolic resin with cotton flock by airblasting the ingredients at high speed against a surface, masticating the mixture, cooling it rapidly and grinding it.

HOLLOW ARTICLES. H. Dreyfus (to Celanese Corp. of America). U. S. 2,285,502, June 9. Forming hollow articles by coating a porous mold with a soluble solid (insoluble in solvents for the article to be made), applying a film-forming solution and loosening the deposited film by applying a solvent for the solid undercoater from inside the porous mold.

METHYLCELLULOSE. A. A. Houghton and C. M. Taylor (to Imperial Chemical Industries Ltd.). U. S. 2,285,514, June 9. Making low-substituted methylcellulose by mercerizing cellulose and methylating with dimethyl sulfate.

(*Please turn to page 88*)

CELLULOSE ESTERS. G. W. Seymour and Blanche B. White (to Celanese Corp. of America). U. S. 2,285,536, June 9. Acylating cellulose first with acetic or a like acid in presence of sulfuric acid as catalyst, ripening the product, neutralizing the sulfuric acid and acylating the product with a different carboxylic acid.

POLYSTYRENE PLASTIC. E. C. Britton, G. H. Coleman and J. W. Zemba (to Dow Chemical Co.). U. S. 2,285,562, June 9. Interpolymerizing styrene with an ester having at least 2 olefinic double bonds and plasticizing the product.

CONTAINER. J. L. Rodgers, Jr., and C. E. Slaughter (to Plaskon Co.). U. S. 2,285,614, June 9. A urea-formaldehyde resin is formed into a container and lined first with metal foil, then with a waterproof thermoplastic resin.

NONSPLITTING MOLDINGS. P. A. Pontius (to Westinghouse Electric & Mfg. Co.). U.S. 2,285,679, June 9. Moldings which resist splitting under directional stresses are made of laminated resin-impregnated fabric, the laminations in the preform being perpendicular in each part of the molding to the main stress direction to which that part will be exposed.

POLARIZING SYSTEMS. E. D. Bailey (to E. I. du Pont de Nemours and Co.). U. S. 2,285,792, June 9. Facing a polarizing screen with a sheet of birefringent linear superpolyamide which has been permanently stretched under stress.

RESINS. A. Bellefontaine, H. Bernard and A. Sieberg. U. S. 2,285,797, June 9. Heating a drying oil or an oil-compatible resin with a diallyl or dicrotyl ether of a polyhydric polynuclear phenol.

WATERPROOFED FOIL. R. T. K. Cornwell and C. M. Rosser (to Sylvania Industrial Corp.). U. S. 2,285,852, June 9. A nitrocellulose lacquer containing a thermosetting urea resin and a plasticizer is applied to a transparent foil to waterproof it.

KNOBS. Jos. A. Gits and Jules P. Gits. U. S. 2,285,963, June 9. Controlling shrinkage in molding knobs or the like from thermoplastics, and eliminating shrinkage marks on the surface of the moldings.

CELLULOSE ACETATE PLASTICS. R. L. Stern (to Hercules Powder Co.). U. S. 2,286,041, June 9. Making transparent, nearly colorless plastics from cellulose acetate, a heat-stable plasticizer, a blue dye and an acidic stabilizer to prevent decomposition and discoloration at molding temperatures.

VINYL INTERPOLYMER. F. E. Condo, C. J. Krister and W. E. Lundquist (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,286,062, June 9. Producing partially hydrolyzed and partially neutralized interpolymers of maleic anhydride and vinyl compounds.

PHOTOGRAPHIC EMULSION. W. G. Lowe (to Eastman Kodak Co.). U. S. 2,286,215, June 16. Dispersing a silver halide in polyvinyl alcohol, reversibly gelled with a polyhydric phenol or a dihydric naphthol.

PRINTING PLATES. Ralph H. McKee. U. S. 2,286,220, June 16. Forming hardenable printing plate compositions from a mixture of cellulose acetates (differing in viscosity) with a resinous product, a plasticizer and a solvent.

WATERPROOF RESIN. K. E. Ripper (to American Cyanamid Co.). U. S. 2,286,228, June 16. Condensing dicyandiamide: melamine mixtures with formaldehyde to make resins which withstand boiling water.

ACRYLATE INTERPOLYMERS. H. W. Arnold (to E. I. du Pont de Nemours and Co., Inc.). U S. 2,286,251, June 16. Interpolymerizing halogenated acrylate esters, acrylamide or acrylonitrile with an alkyl or aryl ester of maleic or a like acid.

CHLOROPRENE PACKING. Samuel C. Carter. U. S. 2,286,260, June 16. Molded or bulk packing material is made of comminuted chloroprene polymer with flattened soft metal shot distributed through it, and a chloroprene cement as binder.

CHLOROACRYLATE RESIN. J. W. C. Crawford and Nancy McLeish (to Imperial Chemical Industries, Ltd.). U. S. 2,286,264, June 16. Clear transparent resins are obtained by interpolymerizing methyl alpha-chloroacrylate with 10–30 percent of vinyl acetate.

FLAMEPROOFING FOILS. C. M. Rosser (to Sylvania Industrial Corp.). U. S. 2,286,308, June 16. Flameproofing transparent wrapping foils by adding an alkylguanidine phosphate.

PLASTICIZER. G. W. Seymour and Blanche B. White (to Celanese Corp. of America). U. S. 2,286,314, June 16. Plasticizing cellulose esters or ethers with an alkyl-aryl ether of diethyleneglycol or of higher polyglycols.

OIL ACID MODIFIED ALKYD. Edwin T. Clocker. U. S. 2,286,466, June 16. Condensing maleic acid first with an unsaturated oil acid, then with a polyhydric alcohol.

CHLOROPRENE ADHESIVE. J. L. Perkins (to B. B. Chemical Co.). U. S. 2,286,505, June 16. Making a liquid cement from chloroprene and 1 to 10 percent of ethylcellulose in an organic solvent.

POLARIZERS. Leon Pollack. U. S. 2,286,569 and 2,286,570, June 16. Applying a film of plastic to a transparent foil and stretching the foil to orient dichroic particles in the plastic; and blacking out the windows of a room lighted with polarized light by facing the windows with a suitably arranged polarizing surface.

TRANSPARENT FOILS. Ernest Bleiber. U. S. 2,286,595, June 16. Regenerating cellulose foils from aqueous cellulose derivative solutions and drying the resulting foils on a roller train passing through a drier.

CELLULOSIC MOLDINGS. R. O. Phillips and E. H. W. Rottsieper (to Forestal Land, Timber and Railways Co., Ltd.). U. S. 2,286,643, June 16. A natural cellulosic material containing catechol tannins is mixed with a formaldehyde-yielding reagent and made into moldings.

ALKALIPROOF RESIN. C. J. Mighton (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,286,752, June 16. A resin which is soluble in dilute acid but not in water or dilute alkali is formed by condensing a primary or secondary aliphatic amine with an alcohol-modified urea resin.

INSULATED WIRE. W. I. Patnode (to General Electric Co.). U. S. 2,286,759, June 16. Baking a vinyl acetal resin film on a wire conductor and drawing the coated wire to a smaller diameter.

COATING FOR PLASTER. R. S. Shutt (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,286,767, June 16. An undercoater for protecting the finish coat on plaster or stucco from attack by alkali is composed of an alkaliproof vinyl, acrylonitrile or acrylate resin plasticized with a glycol diaryl ether.

FIBROUS INSULATION. V. L. Johannessen (to Western Electric Co.). U. S. 2,286,807, June 16. Insulating conductor wires with a composition of paper pulp and a cashew nut oil resin.

FILM SCRAP. C. J. Malm and G. B. Bachman (to Eastman Kodak Co.). U. S. 2,286,822, June 16. Acetate film scrap from which the emulsion has been removed is leached with an organic liquid fortified with a surface-active compound but having no action on the film base. *(Please turn to page 90)*

ELECTRIC CABLES. J. J. Morrison (to American Steel and Wire Co.). U. S. 2,286,826 and 2,286,827, June 16. Single conductor units in a portable power cable have their rubber insulation jacketed with a cellulose acetate antifriction tape; and the units of a similar cable are enclosed in a jacket of thermoplastic insulation.

VULCANIZED FIBER. G. E. Landt (to Continental-Diamond Fibre Co.). U. S. 2,286,968, June 16. Passing cellulosic webs continuously through peptonizing, leaching and puring baths and laminating the product.

MOLD CORE. E. C. Nocar (to Permold Co.). U. S. 2,286,-994, June 16. A piston mold core has a central section and two pairs of outer sections, the central section being withdrawable.

BOTTLE CAP LINER. J. W. Raynolds (to Raolin Corp.). U. S. 2,287,063, June 23. The paper liner of bottle caps is waterproofed and grease-proofed with a composition of rubber chloride and vinyl acetate resin.

ARTIFICIAL WOOL. V. R. Hardy and J. B. Miles, Jr. (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,287,099, June 23. Melt-spinning a filament from a synthetic linear polyamide, wetting it with a swelling agent, partially cold-drawing the wet filament, releasing the tension and drying the relaxed filament.

RUBBER ARTICLES. G. Schneider (to Celanese Corp. of America). U. S. 2,287,139, June 23. A fabric used in making rubber articles has its weft made of a fusible synthetic resin.

STABILIZED RESINS. L. A. Matheson and R. F. Boyer; L. A. Matheson, R. F. Boyer and G. H. Coleman (to Dow Chemical Co.). U. S. 2,287,188 and 2,287,189, June 23. Protecting polystyrene type resins from photochemical discoloration by adding a high-boiling amine; and stabilizing vinylidene chloride resins with aryloxy-alkyl esters of unsaturated acids.

ELECTRICAL STRESS GRADING. T. R. Scott and J. K. Webb (to International Standard Electric Corp.). U. S. 2,287,-201, June 23. Winding alternating insulating tapes and conducting layers around a core, applying a polymerizable compound to the surface layer and heating to polymerize it, in order to form a stress grading device.

INJECTION MOLDING. C. D. Ryder (to Cretelite Co., Inc.). U. S. 2,287,277, June 23. Enclosing a pellet of thermoplastic in a frangible container, inserting it while hot in an injector chamber and injecting the pellet from the container into a mold.

SLIDE FASTENERS. N. J. Poux (to Talon, Inc.). U. S. 2,287,323 and 2,287,324, June 23. Bonding a resilient flexible stringer to fastener elements; and molding a stringer with attached fastener elements.

COATED PAPER. J. G. Hayden, Jr. (to West Virginia Pulp and Paper Co.). U. S. 2,287,348, June 23. Bonding a clay coating to paper with a cellulose ester or ether or with polystyrene, a vinyl ester or acetal resin or an acrylate resin.

BOTTLE CAP. C. E. McManus, G. B. Cooke and V. A. Ryan (to Crown Cork and Seal Co., Inc.). U. S. 2,287,388, June 23. Cushion liners of crown caps are faced with a gastight film of chlorinated rubber, hardened and toughened by adding a hard resin and a plasticizer.

MASTIC TILE BINDER. F. W. Corkery and R. H. Bailey (to Pennsylvania Industrial Chemical Corp.). U. S. 2,287,513, June 23. Use of a high coumarone-indene polymer and a nonvolatile plasticizer in mastic tile binders.

REEDS. Mario Maccaferri. U. S. 2,287,529, June 23. Forming reeds for saxophones, clarinets and the like from a plastic composition.

ADHESIVE CEMENTS. P. O. Powers (to Armstrong Cork Co.). U. S. 2,287,535 and 2,287,536, June 23. Interpolymerizing a terpene with a coumarone-indene fraction in presence of aluminum chloride; and forming an adhesive by condensing formaldehyde with a mixture of urea and phenol.

GLASS-COATED LENS. F. J. Binda (to Polaroid Corp.). U. S. 2,287,546, June 23. Applying an extremely thin hot film of glass to a cellulose acetate lens to effect adhesion without damage to the lens.

TRANSLUCENT SCREEN. E. H. Land (to Polaroid Corp.). U. S. 2,287,556, June 23. Forming screens from ethylcellulose and benzylcellulose, one being in fine discrete particles and the other in a sheet which forms the continuous phase.

POLARIZERS. C. H. Brown (to Polaroid Corp.). U. S. 2,287,598, June 23. Embedding fine parallel wires in a sheet of plastic, heating the wires to plasticize the sheet and stretching the hot wires and plastic.

UREA RESIN. A. Brookes (to American Cyanamid Co.). U. S. 2,287,756, June 23. Mixing a hardenable urea-formaldehyde resin with 2–10 percent of melamine, or of a melamine salt.

RUBBER DERIVATIVES. R. G. R. Bacon, Wm. Baird, B. J. Habgood and L. B. Morgan; R. G. R. Bacon, B. J. Habgood and R. Hill (to Imperial Chemical Industries Ltd.). U. S. 2,287,774–5, June 30. Partially saturating the double bonds in natural rubber with dithiocyanogen to improve oil resistance and other properties; or forming similar products from dithiocyanogen and butadiene, isoprene, chloroprene or the like.

RESIN AND ACETATE PLASTIC. R. Canter (to General Motors Corp.). U. S. 2,287,930, June 30. Compounding cellulose acetate with 5 to 40 percent of urea-formaldehyde resin.

INSULATED WIRE. R. W. Shoemaker (to Chase Brass and Copper Co.). U. S. 2,287,947, June 30. Weatherproof insulated wire is coated first with ethyl cellulose containing asphaltum, then with a sheath of fine wire between two layers of fabric and finally an outer coat of asphaltum containing ethyl cellulose.

ALKYD RESIN ENAMEL. D. M. Gowing and P. F. Sanders (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,287,986, June 30. An enamel made with an oil (or oil acid) modified alkyd resin and diphenylguanidine.

CERAMIC PRODUCT. J. D. Sullivan and C. R. Austin (to Battelle Memorial Institute). U. S. 2,288,047, June 30. Incorporating up to 20 percent of a resin in baked but unburned slip-cast ceramic articles.

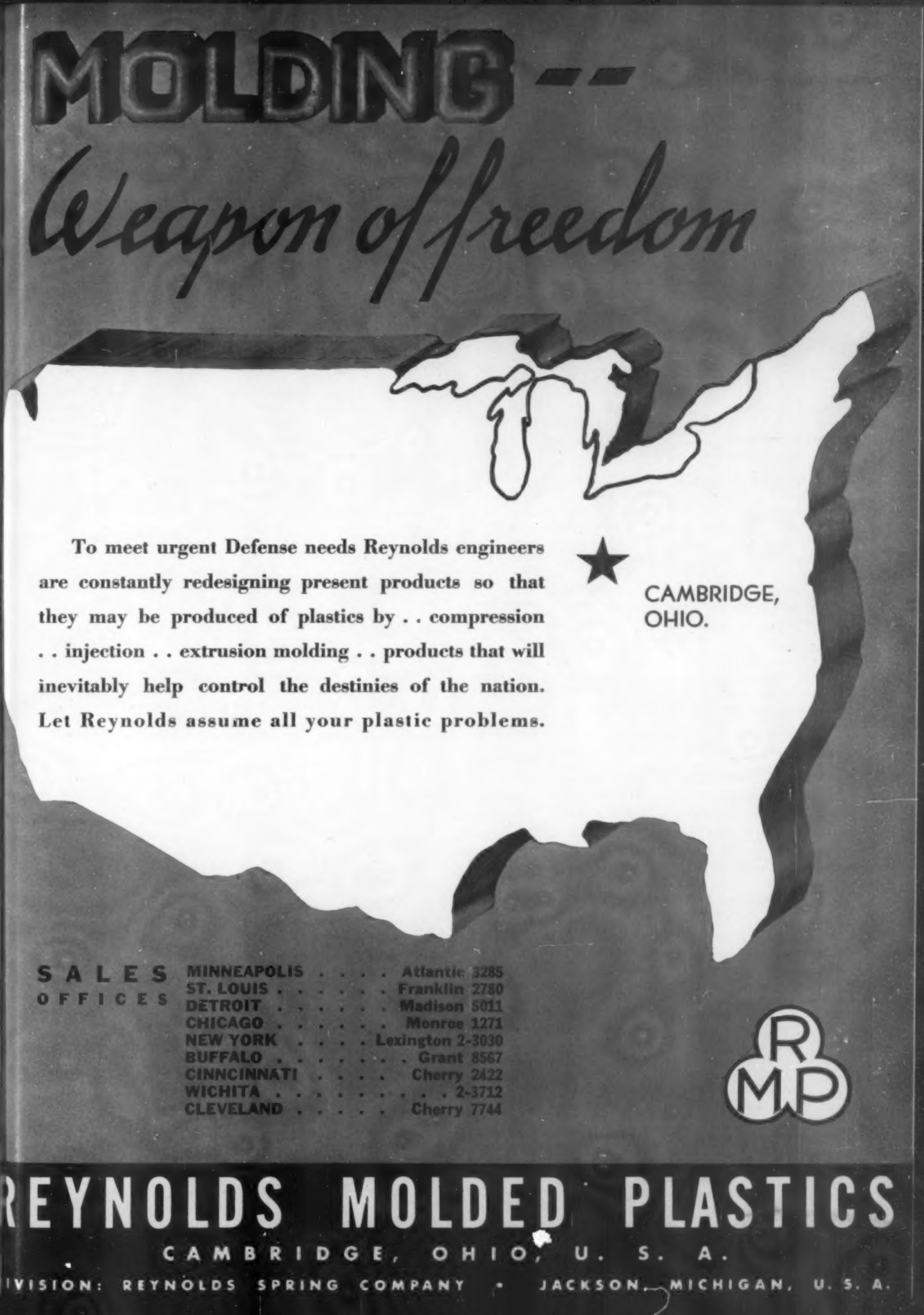
HECTOGRAPH BLANKET. J. Bjorksten (to Ditto, Inc.). U. S. 2,288,152, June 30. Using a dyed vinyl resin gel as copy mass on a hectograph blanket.

CAN LINING. L. P. Curtin (to Curtin-Howe Corp.). U. S. 2,288,182, June 30. Bonding a thermoplastic chemically inert film to the inner surface of food tins by means of a chromium compound.

COUNTER WHEELS. Jos. A. and Jules P. Gits. U. S. 2,288,187, June 30. Molding numerals into the rim of wheels for counting devices.

CELLULOSE ETHERS. Georg Meyer. U. S. 2,288,200, June 30. Forming cellulose ether powder from thin films produced by hot casting from aqueous solutions of water-soluble cellulose ethers.

SUPERPOLYAMIDE. H. Hopff, A. Weickmann and H. Ufer (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,288,279, June 30. Dissolving a synthetic linear superpolyamide in formic acid and condensing it with formaldehyde.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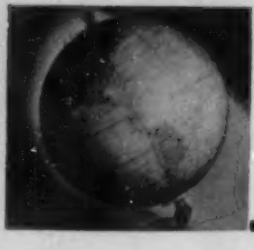


Foreign plastics patents

Application dates are given for patents of European countries, but for Canada the issue date is given

METER HOUSINGS. Landis und Gyr Akt. British Patent 519,295, April 18, 1940. Molded synthetic resin housings for sensitive electric meters are coated (by spray or brush) with a bronze or aluminum bronze lacquer.

SUPERPOLYAMIDES. E. I. du Pont de Nemours and Co., Inc. Belgian Patent 436,377, May 3, 1940. Properties of fabrics or films made of linear superpolyamides are improved by heat treatment in presence of formaldehyde.

ARTIFICIAL STONE. Alexander Wacker Ges. für elektrochemische Industrie G. m. b. H. French Patent 854,531, April 17, 1940. A vinyl resin in powder or emulsion form is incorporated with cement or plaster, made up with water, formed in shapes and heated to 60-80 deg. C.

CONDENSER DIELECTRICS. F. J. Brislee, B. Welbourn, H. Higham, J. C. Quayle and H. B. Chapman (to British Insulated Cables, Ltd.). British Patents 511,580, Sept. 14, 1939; 514,156, Nov. 30, 1939; 517, 649, Feb. 29, 1940. Ultrapure high-boiling hydrocarbons can be used to plasticize polyethene and polystyrene resins, for use in electric condensers, without the usual loss in dielectric properties caused by plasticizing these resins; suitable plasticizers include acid-condensed diamylnaphthalene and mildly polymerized methylstyrene or isobutylene products.

LEATHER SUBSTITUTES. Otto Hauffe (to Deutsche Celluloid-Fabrik). German Patent 700,175, Dec. 14, 1940. Artificial leather is made of at least two layers of plasticized water-insoluble vinyl resins alternating with perforated interlayers of the same resin but without a plasticizer.

CHINTZ EFFECTS. W. Kershaw and C. J. Whitelegg (to Bleachers' Association, Ltd.). British Patent 521,906, July 4, 1940. Rayon or other fabric is coated with an interpolymer of ethyl acrylate and vinyl isobutyl ether, dried, calendered, coated with a thermosetting alkyd or urea-formaldehyde resin and heated to set the final resin film.

STABILIZED ACETAL RESINS. British Thomson-Houston Co., Ltd. British Patent 518,006, March 14, 1940. Stabilizing vinyl acetal resins against hardening in the injector during injection molding, the stabilizer being up to 2 percent of an alkylamine, alkanolamine, alkylene diamine, arylamine or naphthylamine.

STRESS-FREE MOLDINGS. Röhm und Haas Akt. British Patent 518,220, March 21, 1940. Molding shaped articles without internal stresses by forming an aqueous dispersion of equal parts of methyl (or ethyl) acrylate and methyl (or ethyl) methacrylate resins, coagulating the dispersion by adding an electrolyte, compounding with fillers, pigments or plasticizers and molding the product.

THERMOPLASTICS. Imperial Chemical Industries, Ltd. Belgian Patent 436,091, May 3, 1940. Thermoplastics with exceptionally useful properties are obtained by blending two or more halogenated polyethenes differing in halogen content.

ACRYLATE POLYMERS. Imperial Chemical Industries, Ltd. Belgian Patent 436,030, May 3, 1940. Properties of acrylate resins are improved by polymerizing the monomer slowly, e.g., by adding sufficient inhibitor to prevent polymerization below 100 deg. C. and to make the process about 4 times as slow as in absence of inhibitor.

VINYL CHLORIDE. I. G. Farb. Akt. British Patent 517,689, March 7, 1940. Raising the softening point of vinyl chloride resin moldings, e.g., from 70 to 95 deg. C., by chlorination with gaseous or dissolved chlorine.

SAFETY GLASS. I. G. Farb. Akt. French Patent 853,105, March 11, 1940. Water-repellent interlayers with high adhesive strength are made by condensing polyvinyl alcohol with alkylcyclohexanones.

TRANSPARENT HEATER UNITS. Axel B. Kjellström. Canadian Patent 400,771, Nov. 18, 1941. Embedding flexible electric heating wires in a core of a flexible transparent cellulose derivative and facing the core on both sides with a transparent flexible sheet of cellulose derivative.

STYRENE RESIN. H. M. Stanley (to Distillers Co., Ltd.). Canadian Patent 400,837, Nov. 18, 1941. Plasticizing polystyrene with 5 to 45 percent of a purified hydrocarbon.

EMULSION POLYMERIZATION. A. Renfrew and W. E. F. Gates (to Canadian Industries, Ltd.). Canadian Patent 401,781, Dec. 30, 1941. Polymerizing *n*-propyl methacrylate in aqueous emulsion in presence of a phthalate, tartrate or phosphate plasticizer to form an emulsion lacquer.

AMIDE RESINS. H. J. Tattersall (to Canadian Industries, Ltd.; to Imperial Chemical Industries, Ltd.). Canadian Patents 401,795; 401,849, Dec. 30, 1941. Heat-hardenable resins which are soluble in organic solvents are made by condensing formaldehyde and a primary alcohol with the initial condensation product of formaldehyde and an amide such as urea, guanidine, semicarbazide or biuret; or by condensation of formaldehyde with an ester-amide of a dicarboxylic acid.

EXTRUDING PLASTICS. E. J. Roth and J. L. Ellis (to Joe Lowe Corp.). Canadian Patent 402,050, Jan 6, 1942. Evacuating the space below a column of plastic so that the material is extruded under atmospheric pressure, and shaping the extruded plastic, flow being stopped at the desired point by breaking the vacuum.

RESIN EMULSIONS. Röhm und Haas Akt. Italian Patent 382,125, Nov. 2, 1939. Producing acrolein resins in aqueous emulsion.

SUPERPOLYAMIDES. I. G. Farb. Akt. Italian Patent 382,553, May 11, 1940. Condensing difunctional amide-forming reagents to form linear polyamides having exceptionally high molecular weight.

STABILIZING RESINS. Societa Italiana Pirelli. Italian Patent 381,013, Feb. 2, 1940. Increasing the lightfastness and thermal stability of vinyl resins.

PLASTICIZERS. Societa Elettrochimica del Toce. Italian Patent 380,472, Jan. 24, 1940. Synthesizing aliphatic carboxylic acids such as adipic acid for use in making plasticizers and synthetic resins.

OILPROOF PLASTICS. A. Weihe (to I. G. Farb. Akt.). German Patent 703,126, Jan. 30, 1941. Foils, films and sheets of plastic material which resists oils, gasoline and other solvents are produced by plasticizing a hydrophilic resin such as polyvinyl alcohol with thioglycols such as trithiodiglycol or dithiodibutyleneglycol.

Publications

Write direct to the publishers for these booklets. Unless otherwise specified, they will be mailed without charge to executives who request them on business stationery. Other books will be sent postpaid at the publishers' advertised prices

Modern Plywood

by Thomas D. Perry

Pitman Publishing Corp., 2 W. 45th St., New York, 1942

Price $4.50 **366 pages**

This timely and outstanding contribution concerning the product of a relatively new industry, now closely allied to the plastics industry through resinous bonds, merits particular attention because of the author's association with the development of plywood from its early beginnings in the United States. This background of experience is continuously reflected throughout his discussion of veneer manufacturing and adhesives, and their combination to make plywood. Recent advances in resinous bonding materials, electrostatic heating, flexible-bag molding, and high-density plywood, which are leading to realignment of factory procedure, are reviewed. The industrial applications of plywood are described in detail. Section on testing, glossary of terms and tabular data on the properties of veneers and plywood will be of especial interest to engineers. A bibliography covers the literature of the industry, particularly with respect to the growing technique of resinous adhesives.

This authoritative picture of the rise of plywood and its expanding outlets, attributable mainly to the improved durability characteristics of resin bonds, is alone in its field. Both the author and publisher are to be congratulated on a job well done.

G. M. K.

Plastic Molding

by D. A. Dearle

Chemical Publishing Co., Inc., 236 King St., Brooklyn, 1941

Price $4.00 **131 pages**

This textbook was prepared by the author "to give the student or layman a general knowledge of plastics and the numerous phases of manufacturing methods." The introduction also indicates that the last few chapters "contain some information which may prove to be of value to even those who are well versed in the industry," and that "the examination questions should serve to test the extent of their understanding of the business." The book is referred to on the title page as a "comprehensive study." However, it is doubtful whether, for example, a chapter on "Engineering and Design" comprising 8 pages or about 2500 words should be called comprehensive. This reviewer would prefer to consider the book purely as an elementary introduction to molding plant operation. Viewed from that angle it is a commendable job and should be of benefit to beginners. G. M. K.

★ A HANDSOME, SPIRALLY BOUND, 169-PP. BOOKLET has just been issued by the Monsanto Chemical Co., St. Louis, Mo. The avowed purpose of the book is "to bring together, in the most convenient and useful form possible, sufficient information on all Monsanto products to serve as a buying guide and to enable users of chemicals to determine whether a material unfamiliar to them is of sufficient interest to merit further consideration." The booklet contains a classification of products according to industries; and a general data section contains a variety of physical and chemical information in connection with some of the products described in an alphabetical listing.

Wood Technology

by Harry Donald Tiemann

Pitman Publishing Corp., 2 W. 45th St., New York, 1942

Price $3.50 **316 pages**

The story of wood, its structure and characteristics, its processing and treatment, and its conversion into improved industrial products through scientific investigations in wood anatomy, wood physiology, timber physics, wood chemistry and timber mechanics is told in the simple terms of the classroom. This excellent survey of all significant phases of wood technology is based on the author's 35 years of experience in research and teaching at the U. S. Forest Products Laboratory, the University of Wisconsin and the Yale School of Forestry. G. M. K.

★ A HANDSOME, 40-PAGE BOOKLET CALLED *THE Nitroparaffins—New Worlds for Chemical Exploration*, has just been issued by the Commercial Solvents Corp., 17 E. 42nd St., New York City. Illustrated with photographs of equipment, charts, graphs and full tables, the booklet covers the reactions, uses, properties and various derivatives of the four nitroparaffins now being produced commercially. Formulas are included to illustrate many of the applications of the nitroparaffins and their derivatives.

★ THE DUREZ PLASTICS & CHEMICALS CO., NORTH Tonawanda, N. Y., has just published an 8-page folder called "Durez Plastics—From the Raw Materials to the Finished Product." Simple, non-technical language is used to describe the processes, properties and applications of Durez products. Fully illustrated, the booklet will make interesting and informative reading for the layman interested in learning more about plastic materials, and a brief bibliography will serve as a guide to his future reading.

★ ELEMENTARY PLASTICS PROCESSES IS THE TITLE of a 26-page book prepared and published by Albert Kosloff of the Industrial Arts Laboratory, Waller High School, Chicago, Ill. It discusses the molding and machining of plastics, and contains instructions for hand fabriction of various small novelties. The text has been graded by word lists to elementary school level.

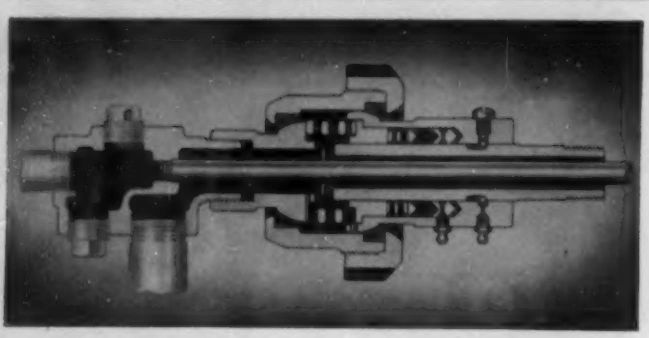
★ CATALOG NO. 5 FROM THE AIRCRAFT SCREW Products Co., Inc., Long Island City, N. Y., contains tabular and diagramed descriptions of the variety of screws, nuts, bolts, studs, inserts and tools which this company manufactures. Full dimensions of each item are furnished.

★ A 6-PAGE FOLDER ISSUED BY ELMER E. MILLS Corp., Chicago, Ill., describes briefly the new Mills Plastic tubing and fittings, newest thermoplastic replacement for metal. The folder contains technical data and physical properties of the new application, as well as detailed graphs showing the relation between bursting and working pressures vs. temperatures for the various sizes available.

★ USERS OF HIGH-PRESSURE, MOTOR-DRIVEN pumps will be interested in the 8-page illustrated booklet issued by the Watson-Stillman Co., Roselle, N. J., which presents their line of vertical pumps, including simplex, duplex and triplex types in a wide range of models and capacities.

★ THIRTY-EIGHT PAGES OF BRAND NEW INFORMATION, including charts, tables, diagrams, are now available from the Haveg Corp., 6 Chapel St., Newark, Del., in a new catalog which lists all types of products and equipment made of this material. Photographs showing pipes, ducts, pumps, tanks, etc., are supplemented by textual discussions of the best methods of installation, service recommendations, special design features, dimensions and other information that should be helpful to users as well as to potential users of corrosion-resistant equipment.

Machinery and Equipment



★ BARCO MFG. CO. HAS JUST DEVELOPED A NEW type of revolving joint, 7RB-8CRB (above), which is reported capable of handling steam, air, oil, gas, water and other fluids. It is constructed with two ball seats which permit a slight flexing angle to relieve strain on the piping because it pulls together nipples and unions. The joint is also equipped with a ball race arranged so that the sleeve has a slight tendency to move in and out for expansion of the steam-heated cooling rolls.

★ IT IS GENERALLY KNOWN THAT IF MICROMETERS, gages, etc., are held in the hand, body heat will distort them sufficiently to make accurate measurements impossible. George Scherr Co., Inc., has therefore devised a new tool stand for the purpose of holding securely micrometers or snap gages used for serious measurements. Said to be constructed so that it will not damage the finish of the frame, its jaws are parallel without serrations, and a small piece of scotch tape on the inside will hold the tool firmly without exerting too much pressure. The jaws may be swiveled from vertical to horizontal position. Base of the stand is cast iron, jaws of cold rolled steel.

★ A NEW ROTARY-CUTTER SCRAP GRINDER (ABOVE) which is reported to save about 600 lb. of metal has recently been developed by the Ball & Jewel Co. The new model is compactly constructed and occupies just about half as much floor space as earlier machines. It operates on a V belt drive, instead of the old shaft drive, and features a removable hopper which collects the material as it is ground. Equipped with 3 interchangeable screens for different sized granulations, and 10 solid tool steel knives for grinding and outboard SKF bearings, the grinder runs on a 5 to 10 h.p. motor.

★ THE PYROVAC, A NEW RADIATION PYROMETER, has recently been developed by the Bristol Co. for recording, indicating or automatically controlling temperatures in furnaces and kilns above 900° F. The temperature-sensitive unit or radiation head is mounted on the outside of the furnace out of the hot zone, where it picks up heat rays emitted from the object under measurement, thus registering surface temperatures.

★ HAMMOND MACHINERY BUILDERS ANNOUNCE their new models 10 and 14 (above) carbide tool grinders equipped with concealed No spray—No splash guards. The models are equipped with 10-in. and 14-in. diameter silicon carbide wheels, respectively, which are available for either wet or dry grinding. For wet grinding the coolant system includes a coolant pump and a coolant supply tank in the base, with spouts and shut-off valves at each side of each wheel. Model 10 is powered by a two-h.p. and model 14 by a 3-h.p. reversing motor. Both models are totally enclosed, fan-cooled and controlled by a reversing magnetic switch and push button control.

★ TWO NEW LARGER CAPACITY PORTABLE CONtrolled Flow Coolant Pumps, for attachment to drill presses, lathes, grinders, saws, tappers, milling machines and other cutting tools as well as "Flo-Bac" Pans and "Flo-Bac" Fittings have been recently announced by Gray-Mills Co., Inc. The new pumps, designated G-2 and G-3 have capacities of 75 and 130 gallons per hour with pressures of 20 and 30 lb., respectively. These compare with a capacity of 50 g.p.h. and 10 lb. for the original Model G-1. Model G-2 is recommended for 1 to 4 spindle drill presses, lathes, small hand screw machines, grinders, small milling machines. Model G-3 is recommended for 4 to 8 spindle drill presses, cut-off machines, large milling machines, large hand screw machines and engine lathes.

In the plastics picture

★ THE PUBLISHER AND STAFF OF MODERN PLASTICS magazine announce with regret the resignation of Editor L. T. Barnette. Mr. Barnette, who is secretary of the John Wesley Hyatt Award Committee (see November 1941 MODERN PLASTICS), will for the present devote his attention exclusively to this activity. His new work, which will bring him in frequent and intimate touch with all phases of the plastics industry, should result in a significant contribution to the field. The sincere good wishes of the entire staff of MODERN PLASTICS accompany Mr. Barnette in his new endeavors.

★ ON JULY 14, 1942, A CONFERENCE WAS HELD IN Philadelphia to discuss the development of a classification system for plastics which could be used as a basis for grouping and identifying plastic compositions for specification purposes. This conference was the outgrowth of a meeting of the Specifications Subcommittee of the A.S.T.M. Committee D-20 on Plastics held in Atlantic City recently. The Philadelphia conference was attended by the following delegates—listed by organizations:

American Society for Testing Materials, Committee D-20 on Plastics
Robert Burns, Chairman; G. M. Kline, Chairman, Specifications Subcommittee
Army-Navy-Civil Technical Subcommittee on Plastics
Lt. David Grimes, G. M. Kline
Federal Specifications Technical Committee on Plastics
G. M. Kline, Chairman; Capt. E. T. McBride, Vice Chairman National Electrical Manufacturers' Association, Laminated Products Section
R. R. Titus, Chairman, Technical Committee; G. H. Mains
Plastic Materials Manufacturers' Association
J. H. Adams, Chairman Technical Committee
Society of the Plastics Industry
F. W. Warner, Chairman, Technical Committee; W. T. Cruse, Ronald Kinnear, Garson Meyer
U. S. Navy Department, Naval Aircraft Factory
P. M. Field
U. S. War Department, Air Corps
Lt. David Grimes
U. S. War Department, Ordnance Department
Capt. E. T. McBride, H. R. Schaffer

Several methods of classifications were discussed. A second meeting took place at Pittsfield, Mass., on July 21, where further consideration was given to the question of classification of plastics with respect to chemical type.

★ CHARLES REEVES, WHO UNTIL RECENTLY WAS IN charge of the New York Sales Division of Monsanto Chemical Co., is now with the Washington branch. A. C. Martinelli, connected with the sales department for New Jersey territory, has been promoted to the assistant managership of the Plastics Div., New York sales office of that company.

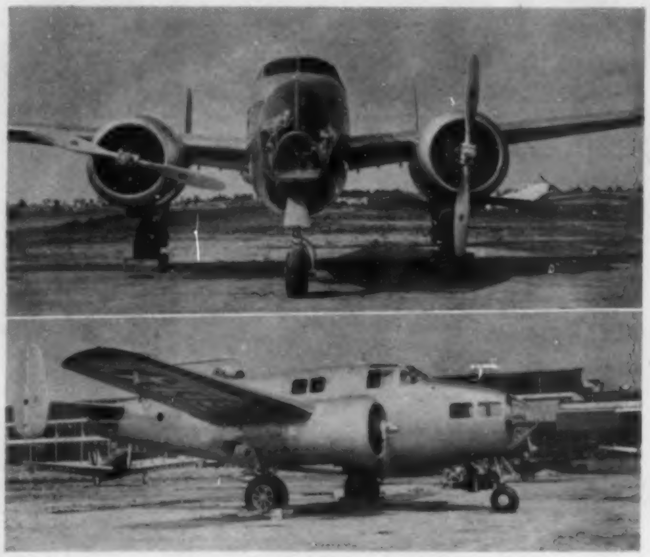
★ WILLIAM LESTER, OF THE CHICAGO OFFICE OF the Celanese-Celluloid Corp., was recently transferred to the New York office to handle sales development.

★ SEAMLEX CO., INC., MAKERS OF METAL HOSE, announces their removal to an enlarged plant and main offices at 27-27 Jackson Ave., Long Island City, N. Y.

★ THE CHEMICAL AND DRUG BRANCH OF THE Office of Price Administration, Regional Office, Union Commerce Building, Cleveland, Ohio, announces that it is very much interested in the problems of the industry in the states of Michigan, West Virginia, Kentucky, Indiana and Ohio. They state that they are particularly anxious to acquaint themselves with various price questions which may arise in the plastics industry.

★ THE FIRST MEETING OF THE NEWLY ORGANIZED Industrial Salvage Committee was held on July 1 at the Hotel Roosevelt, New York City, where the crucial need for scrap materials in the war effort was stressed by R. Merrill Decker, Regional Manager for New York City of the Industrial Salvage Section of the WPB. The objectives of the committee as enunciated by Mr. Decker were the wrecking of abandoned and obsolete machinery and equipment, utilization of all critical materials to the best advantage, minimization of waste and spoilage, re-use wherever possible of blanks, cut-downs, short-ends and clippings, selective handling and segregation of scrap at the source, avoidance of scrap contamination, and speeding the return of scrap and waste through existing channels to mills and refineries.

HARRIS & EWING



Front and side view of new plastic-plywood two-engined crew trainer which has successfully passed Army tests

★ THE NEW FAIRCHILD AT-13 TWIN-MOTORED ADvanced trainer, made almost entirely of plywood molded with plastic resins under heat and pressure by the Duramold process, successfully passed initial tests, it was disclosed by the War Department on July 21. The AT-13 one of the largest and fastest training planes, conforms to the Army Air Force's policy of using wooden training planes to save critical materials, and is built entirely of plywood except for certain units supporting bombing, machine gun, camera, and other equipment. (A technical discussion of the Duramold process may be found on page 74 of this issue—"Strength Characteristics of Plastic-Bonded Plywood" by George B. Parsons.)

★ OTIS REINECKE, OF BARNES & REINECKE, CHIcago, will be in charge of a new course in plastics design scheduled to be introduced at the School of Design in Chicago beginning with the fall semester. Fuller details of courses in plastics included in the curriculum of the School of Design will be found on page 61 of this issue.

★ ISLYN THOMAS, FORMERLY WITH CONSOLIDATED Molded Products Corp., Scranton, Pa., has joined the Ideal Novelty & Toy Co., 23-10 43rd Ave., Long Island City, N. Y., as manager of development and production dept., plastics division.

★ H. D. PAYNE, ADVERTISING MANAGER OF CHIcago Molded Products Corp., Chicago, Ill., has retired from that position, which he had held for 14 years.

★ A. G. HARTMAN, FORMERLY OF ALLIED PLASTICS, is now in charge of the newly formed Plastic Division of the Plastic and Rubber Products Co., Los Angeles, Calif.

(*Please turn to page 100*)

Center Scope is an optical locating tool of 45x magnification. It has a broad field and guide lines for centering. It can be used on any machine tool and provides an easy method to compensate for spindle or adaptor run-out. A precision instrument not affected by wear, temperature or mechanical pressure. In addition to its many advantages, it is attractively priced. You can get your Variable Center Scope for only $97.00 f.o.b. Los Angeles, California. Edge Block is $23.00 additional. Call your Kearney & Trecker dealer or write for Bulletin No. 201A.

A COMBINATION THAT SPELLS *Plus* PRECISION AND SPEED...

The Milwaukee Rotary Head Milling Machine, primarily developed for tool and die making, is increasingly being used to meet peak production demands on a variety of milling operations.

Fast — versatile — flexible — it performs layout, milling, drilling, precision boring and slotting operations with improved accuracy and usually decreases costs. In conjunction with the use of the Variable Center Scope, this machine provides *plus* precision and speed on a wide range of work. The Center Scope will locate edges or layouts to the spindle axis—even within a tenth.

Investigate the Milwaukee Rotary Head Milling Machine and the Center Scope — and the many advantages of this combination for many machining operations in the tool room or the production line.

KEARNEY & TRECKER CORPORATION • Milwaukee, Wisconsin, U. S. A.

Milwaukee MILLING MACHINES

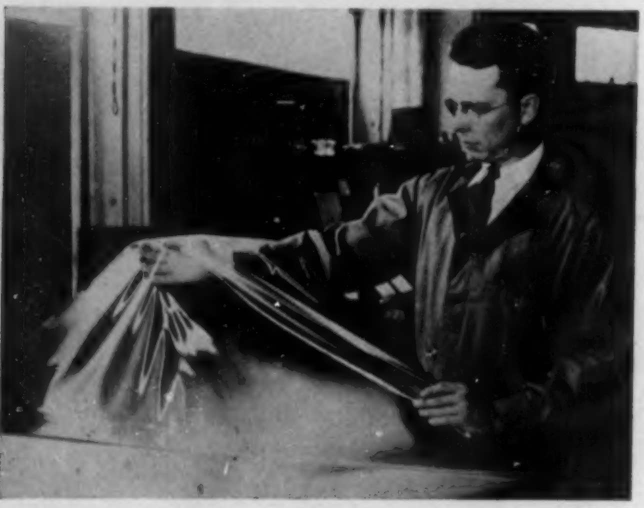
★ BAKELITE CORP., NEW YORK CITY, UNIT OF Carbide and Carbon Chemicals Corp., announces these additions to the Research and Development Laboratories in Bloomfield, N. J.: Robert P. Moffett and Frederick W. Orttung, Jr.

★ DAN G. HUNGERFORD, WHO JOINED THE ELASTIC Stop Nut Corp., Union, N. J., in 1936, and was subsequently made vice president in charge of sales and advertising, has just resigned from that company.

★ J. IRVINE LYLE, PRESIDENT OF CARRIER CORP., and one of its founders, died in Syracuse recently after a three months' illness. In 1902 Mr. Lyle collaborated with Dr. Willis H. Carrier, now chairman of the Board of Carrier Corp., in developing the first scientific air conditioning system, which was the beginning of the air conditioning industry.

★ JOSH MILLER, FORMERLY OF THE DETROIT OFfice of Durez Plastics & Chemicals Co., has moved to Cleveland in an executive position with the United Plastics Co.

★ PLASTICS INDUSTRIES, INC., BEDFORD, OHIO, is a new firm organized to specialize in injection molding thermosetting materials. C. D. Shaw, who has been identified with the process for some time, is with the organization.



★ A NEW PLASTIC-BASE PROTECTIVE COATING FOR ceramic and metal surfaces, called Protektol Stripping Lacquer, has been introduced by Ault & Wiborg Corp., Cincinnati, Ohio. It is reported to be reducing rejects due to rust, surface scratches, grease, shop-wearing and dirt. The new material is completely transparent so that visual inspection of the coated parts is permitted. It is described as being particularly suitable for application to highly polished surfaces such as flat sheets, molds, irregular shapes, dies and bearings which require protection during shipping, storing, handling and fabrication. One gallon, when sprayed to a thickness of one mil, is said to cover approximately 250 sq. ft. of surface. The liquid may be either sprayed, brushed, dipped or roller-coated. Drying time at 200° F. is reported to be 6 to 8 minutes. After being removed from the article it protects (either by lifting or peeling it off, as shown above, or by blowing off with an air jet), the lacquer may be returned and reduced to liquid form again, making possible re-use of the same material. Adhesion is controlled to prevent premature removal.

★ DAYTON INSULATING MOLDING CO. ANNOUNCES that they are now in their new plant at 207 E. Sixth St., Dayton, Ohio, and will maintain two plants for the duration.

★ TRI-STATE MOLDING CO., HENDERSON, KY., IS A new plastics company equipped to do both thermosetting and thermoplastic molding.

★ HURST, INC., FABRICATOR OF CAST PHENOLIC resins, and Northeastern Molding, Inc., compression and injection molders, have formed one company called Northeastern Plastics Corp., 584 Commonwealth Ave., Boston, Mass.

★ A SCHOOL TO ENABLE PLANT AND OFFICE EMployees to gain a greater knowledge of instruments, their construction and their use by America's war industries has been established by Wheelco Instruments Co., Chicago, Ill., manufacturers of industrial temperature measurement and control instruments, combustion safeguard equipment and electronic controllers for industrial applications. Classes are held weekly, with lectures designed with the purpose of broadening the individual employee's knowledge of an instrument's construction features beyond the work in his own particular department, and to familiarize him with the instruments used in industry. Lectures are supplemented by motion pictures on construction and application themes.

★ CONTRACTS FOR TWO MILLION TOOTH BRUSHES with Nylon bristles and an equal number of combs made of plastics were awarded recently at Jersey City Quartermaster Depot. Cost of the tooth brushes was approximately $160,000, combs about $45,000.

★ DANIEL M. SHEEHAN, CONTROLLER OF THE MONsanto Chemical Co., has been elected president of the St. Louis Control of the Controllers Institute of America, and John S. Learoyd, Jr., controller of the Hygrade Sylvania Corp., president of the New England Control.

★ THREE RECENT GRADUATES OF PLASTICS INDUStries Technical Institute received Civil Service appointments recently as junior plastics technologists at the Naval Aircraft Factory, Philadelphia, Penna. Research and development work in the applications of plastics for aircraft are centered at this plant. The three men appointed were Emil Hemming, Jr., Robert Goldsmith and William Renwick.

★ ANNOUNCEMENT IS MADE BY THE SOCIETY OF the Plastics Industry of the winners of the Plastics Industry Merit Awards, won by employees in molding plants who have contributed in an outstanding fashion to the solution of a molding problem. Award winners, who will receive a certificate of merit, in addition to a cash prize of $50 for their achievement, are:

Salvatore Mondalto, Shaw Insulator Co., received the American Cyanamid Award for molding by compression a urea formaldehyde housing for the 1942 Model Schick Dry Shaver.

Harry LeRoy Bortner, American Insulator Corp., received the American Insulator Co. Award for the cold molding of a thin barreled body for a multiple fuse plug.

Edward Schmidt, Shaw Insulator Co., received the E. F. Bachner Award for the construction of the mold to produce the M-52 detonator body.

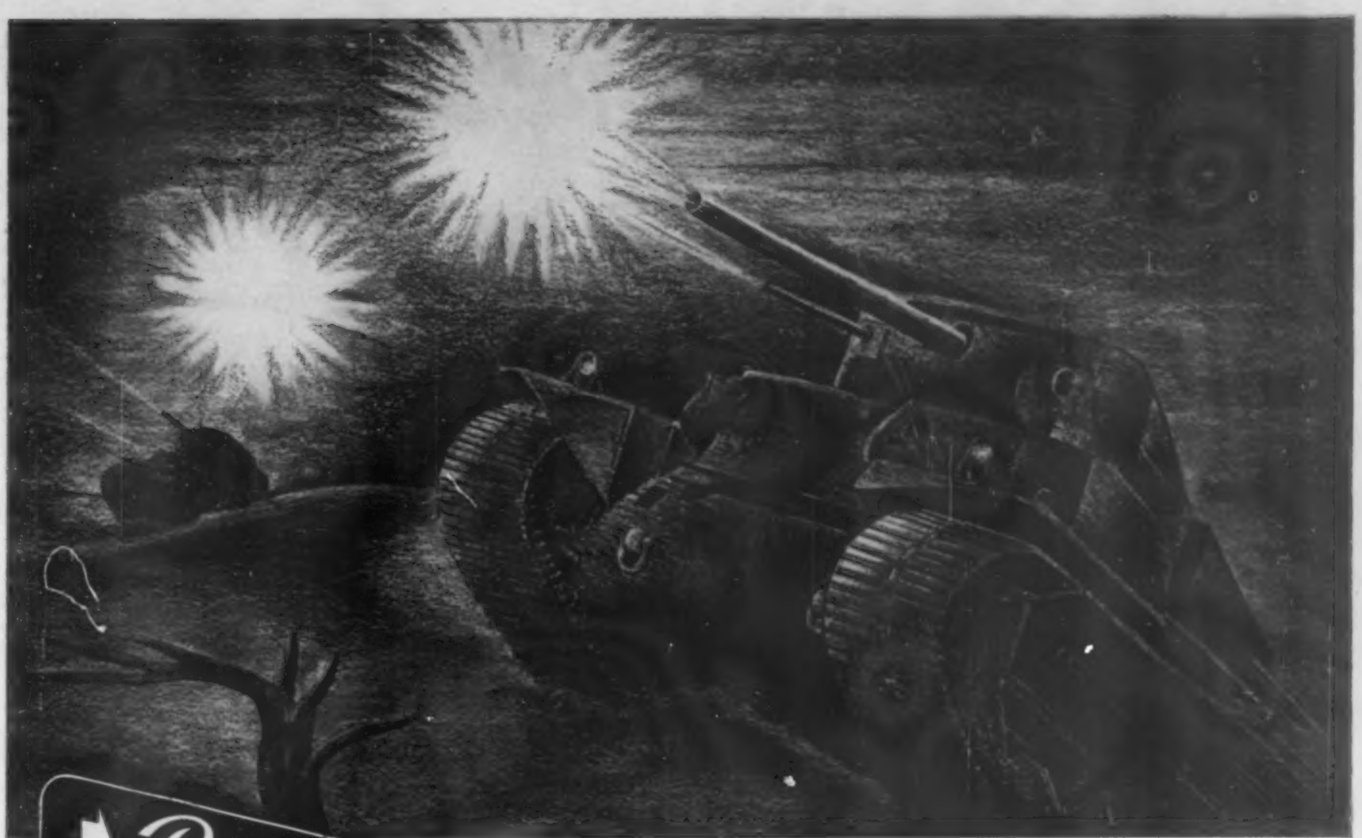
William Dietzen, Chicago Molded Products Corp., received the M. M. Makeever Award for the production of a phenolic compression molded antenna mast.

Stanley Shauver, Chicago Molded Products Corp., received the Frank Shaw Award for initiative in producing parts from a transfer mold for a telephone handset.

The panel of judges consisted of Dr. Gordon M. Kline, U. S. Bureau of Standards; Dr. J. P. Trickey, Plastics Industries Technical Institute; Dr. J. B. Townsend, Bell Telephone Laboratories.

Sorry!

★ IN THE JULY 1942 ANNOUNCEMENT OF THE FORmation of Lester-Phoenix, Inc., the name of Fred Ziesenheim, newly appointed sales manager was incorrectly spelled. Out apologies to Mr. Ziesenheim and to Lester-Phoenix.



Washington Round-Up

Current news, Government orders and regulations affecting the plastics industry, with analyses of the plastics situation

WPB PLASTICS EXHIBIT

The attention of plastics materials manufacturers, molders and fabricators is called to the unique opportunity being given them to demonstrate in concrete and objective fashion the part they are playing in the war effort. It will be to the advantage of the industry to participate fully in this enterprise, and to make its entries as informative and comprehensive as possible.

The Conservation Division of WPB plans to maintain an exhibit of currently interesting plastic items of military and industrial nature that are playing a part in the war program. The display will fulfill two important functions:

1. Illustrate the rôle that plastics, in many forms and shapes, are playing in the overall picture both in their own right and as basically good replacements.

2. Perform a definite service for industry, the U. S. service branches and all Government agencies by graphically portraying the accomplishments of plastics, thereby suggesting further feasible and desirable applications.

The intention and plan is to maintain an up-to-date exhibit so that new plastic developments may be added as soon as they become available. Obviously, to serve its most useful function and remain of current interest, the objects should not be obsolete or applications that have been in use for years unless by unusual circumstance a normal usage has found an interesting new adaptation. In order to present an informative and helpful display it is desirable, wherever a replacement of a more critical material has been effected by the use of plastic, that the part replaced be supplied along with the plastic counterpart.

A short story should accompany every part describing specifically the plastic material used; the material replaced, if any; the part name; the part function; and the field of use. Should information be available as to the quantity of more critical material replaced, those figures would also be highly desirable. The material manufacturer's trade name and the name and address of the molder or fabricator will appear on the descriptive tag attached to the part on display so that representatives of industry, government agencies and the service branches will have a ready reference for sources of supply. Naturally the space allotted for the exhibit is not unlimited, hence discretion should be exercised in submitting only parts that are serving some useful function in the war effort. Furthermore, where one representative part will suffice for a group or where a section of a large part will do, then only that which is necessary should be sent in accompanied, if desired, by an explanation of the further scope of such part.

Relative to the submission of such items:

1. The Conservation Division, War Production Board reserves the right to use the submitted items in whatever manner is deemed most advisable.

2. It will be assumed that wherever the item is of a confidential nature, permission for its use in this display will have been obtained from the proper authority.

All items should be addressed as follows:

G. Holmgren
Conservation & Substitution Branch
Conservation Division
War Production Board
Room 3132, Railroad Retirement Bldg.
Washington, D. C.

PRP INTERPRETATION

Metal Closures Restriction in Toiletries & Cosmetics

With the widespread adoption of the PRP plan for granting priorities assistance, a new phase of the priorities picture is opening up which all plastics materials manufacturers and molders should be aware of and understand.

The underlying reasoning behind PRP is to see that all essential industries and manufacturers in these industries get the materials to produce the amount of finished goods deemed necessary to prosecute the war and keep a lean but sound civilian economy in operation. The helter skelter granting of priority certificates without this central guiding intelligence resulted in confusion and terrific "inflation" of ratings. Inflation of ratings means that gradually it is necessary to grant higher and higher preference ratings to get goods. The PRP plan is an attempt to stabilize the rating structure and make sure that the rating which is granted will reflect the relative importance of the end use of the product which is to be manufactured from the materials on which a rating is granted. It may be true that a rating granted under PRP may not be sufficient to get materials at the time the manufacturer would like to have them. But he should be able to get materials after uses more essential than his have been satisfied.

As PRP has evolved, it becomes evident that the essential civilian uses will be rated from A-3 to A-10. Any rating above A-3 will be reserved for military matériel. The difficult problem which is being faced is to classify end uses so that some uniformity will exist as to the rating granted for the same end use among different raw materials.

As an example of this in the plastics field, the closure situation can be looked at. Under the formaldehyde order (M-25), closures were rated as a B-4 use. Yet at the same time, steel was being given A ratings for the identical purpose of closure manufacture. This obvious inconsistency has been receiving the attention of those charged with stabilizing the rating picture. As a result, the manufacture of closures from all types of plastics for civilian use will be given low A ratings generally. There will be some exceptions to this end and estimates of plastics requirements for closures as filed on PRP applications may be sharply cut in the processing of the application. The important thing is that the ratings granted will have some uniformity, even though they may vary slightly.

There has apparently been much confusion about this re-rating of plastics for closures. Considerable speculation has been voiced in the industry as to why phenolics—apparently quite short just a few weeks ago—may now be used for closures. Modern Plastics has been assured that the re-rating will not result in any diversion of phenolics to closure manufacture from uses more essential to the war effort. As a matter of fact, there would appear to be more business in the offing for both phenolics and ureas than can be handled.

First, a look at the general picture may be worthwhile. Excluding the crown caps used for beer and soft drinks, there are about 90,000 tons of steel used annually for screw type closures. Another 25,000 tons of steel is required for closures for home canning purposes. The critical situation in steel makes it appear inevitable that some other material will have to be used for this closure business and plastics are naturally the first replacement materials that industry will turn to.

In 1941 approximately 15,000,000 (*Please turn to page 104*)

pounds of plastics split about 70 percent phenolics and 30 percent ureas were used by the entire glass container industry. The forced shift to plastic closures in bottling wines and distilled spirits will in itself require approximately 20,000,000 pounds of molding powder which will save some 8000 tons of steel.

To replace metal closures exclusive of those used for process foods or for home canning would require approximately 50,000,000 pounds of molding powder which would exceed the present urea material output by approximately $2^1/_2$ times. It would also be a sizable chunk of the total phenolic output, so that indicates a tremendous potential new market for plastics.

Second, turn to the specific. Very shortly, the tin and terneplate closure order (M-104) is going to be further amended. Among other changes there is one which is scheduled to be put into effect that would forbid the use of *steel (blackplate) for closures for cosmetics and toilet goods after existing inventories of those manufacturers have been exhausted.* In 1941, the cosmetics and toilet goods industry used over 7000 tons of steel for closures. A large part of this business will undoubtedly seek plastics as the replacement material.

In line with this potential of business, molders should begin to lay plans for simplification and standardization of closure molds and sizes. The Containers Branch of WPB wants to get maximum usage out of material. Simplification of design to eliminate all non-functional uses and standardization of output so that maximum molding efficiency can be achieved are two of the principal steps toward this.

Plans are being thought about, also, which would call for a closure return plan in order to get a new jar of toilet goods or cosmetics similar to the toothpaste tube return plan. In lieu of this, there may be some plan worked out where a temporary shipping closure would be placed on the jar to be replaced by the consumer with a standard sized plastic screw cap after the article is bought and taken home. This cap would be used over and over again by the same person after the paper or other temporary closure was punctured at initial use.

One thing must be kept in mind in regard to this business. It will not be gotten without going after it.

M-154 CLAUSES POSTPONED

Plastic materials manufacturers and molders have been notified now by WPB that the effective date of the certification and scheduling clauses of the thermoplastic order (M-154) has been postponed until August 15. July 15 was the effective date originally planned.

In effect, this means that users may order and producers may deliver thermoplastics without any certification that the amount so ordered does not exceed $^1/_{12}$ of the amount consumed by the user during the calendar year 1941. Nor does the user need to set forth the use classification in which his uses of the thermoplastic would fall.

So far as producers are concerned, they need not follow the scheduling provision of Section "D" of the order until August 15.

The purpose of this postponement is to give WPB time to amend certain parts of M-154—such as the $^1/_{12}$ clause—which have been causing some unforeseeable difficulty. For example, one airplane manufacturer was unable to get any more acrylic under the terms of M-154 because he had exceeded his 1941 usage of that material, due to vastly stepped-up plane production.

MATERIAL SHORTAGES LOOM

Manufacturers of end products made from vinyl acetate might as well forget about manufacturing them after September 1 unless they have a preference rating of at least A-10. There was probably enough of the material obtained the first few weeks of this month to make most of the hose for the stirrup pump (see MODERN PLASTICS, July 1942, page 38), but the Army has now moved in and has taken over most of the vinyl material for raincoats.

Aircraft Parts—A special form, PD-4X-1, has been prescribed under terms of Priorities Regulation No. 12, June 26, for use by Armed Services to re-rate some outstanding contracts to give preference to a strategic program of military production by raising level of preference ratings on certain orders for aircraft and parts.

• • •

Aniline—Control and distribution of aniline, important chemical in manufacture of explosives, dyes, synthetic rubber and other chemicals, was established by WPB order M-184 issued July 13.

• • •

Binoculars—WPB has added a military exemption list to copper conservation restriction order permitting use of copper in manufacture of binoculars and valves for ship use after August. This is Amendment 3 to Order M-9-C issued July 13.

• • •

Industrial Machinery Branch—WPB has abolished the special industrial machinery branch, and assigned work of this division to other WPB branches. Order L-159 covering plastics machinery will be administered by the Chemicals Branch under the direction of James A. Lawson.

• • •

Insulated Wiring—Amendment 8 to Order M-15-b-1, July 10, incorporates revised specifications governing use of rubber in insulated wire and cable, expanding restrictions to all military uses in order to save an additional 150 to 200 tons of crude rubber per month. New specifications are applicable to civilian, war and all orders placed by government agencies. An exception is made for certain types of wire and cable requiring heavier than normal insulation, such as submarine cable, military field communication wire and special naval and aviation cable.

• • •

Obtaining Supplies—Prime contractors holding priorities on PD-3A certificates are entitled to use the rating within specified limits for operating supplies and to replace materials in inventory, according to Interpretation 1, Priorities Regulation 3, issued July 14.

Interpretation 2 to Priorities Regulation 11 issued July 13 permits manufacturers operating under production requirements plan to request suppliers to retain orders on books for future deliveries if they are in excess of authorized quarterly purchases.

• • •

Delivery Dates—Provisions of Priorities Regulation No. 1 with respect to meeting delivery dates on rated orders were clarified by a recent amendment providing that when there is a conflict between two orders bearing the same preference rating, the order placed first shall have the preference to the extent necessary to assure delivery on the date specified. This rule holds even if the second order bears an earlier delivery date than the one placed first.

• • •

Stirrup Pumps—General Limitations Order L-39 as amended July 11 provides that stirrup pumps or their parts may be manufactured only to fill orders from the Army, Navy, Maritime Commission, War Shipping Administration, Defense Supplies Corp., or governments of lend-lease countries; pumps containing no non-ferrous metals may be assembled from parts fabricated or semi-fabricated by July 11.

• • •

Priorities—Priorities powers of the chairman of WPB were officially delegated to the newly created office of the Director General of Operations by WPB Regulation 1 as amended on July 14.

• • •

Labor—Manufacturers in communities where labor is critically short will be asked to agree against upsetting the labor market by enticing scarce, skilled labor away from one another. If they don't agree, the Government will set up local controls, it was announced by War Manpower Commission Chairman McNutt recently.

London Letter

AFTER nearly three years of wartime conditions the British plastics industry is in an extremely healthy position, paradoxical though that statement may sound in view of various restrictions on supplies of raw materials. The most significant facts are that the industry is now united as never before, that all firms are cooperating in extensive postwar research schemes, and that even now, despite supply difficulties, more and more new fields are being opened for the use of plastics on important war production work. The shortages of metals, glass, etc., have been responsible for big demands on plastics, and British manufacturers have shown considerable opportunism in meeting these demands, frequently creating entirely new plastics products (or new combinations of plastics materials). Some of the simpler examples of the wider uses of plastics in everyday life are: plastics buttons, plastics National Savings and A.R.P. badges, and utility plastics cups to replace china and tin mugs. Of the more military uses of plastics not a great deal can be said here; phenolic plastics are largely used now as coatings for ammunition; laminated phenolics are an important material in the production of covers for airplanes (also floors); phenolic plywoods have been used for gliders; acrylics are used for instrument lenses, reflectors, windshields, etc.; and cellulose acetate is widely used in production of gas mask parts, handles, knobs, etc.

Supplies

The supply position is tighter, but not unhopeful. Good stocks of casein have been imported from Argentina, and Robert Dodd, general manager of one of our big casein firms, Erinoid, Ltd., has stated that higher stocks of the material are held now than was the case in 1941. Celluloid plastics supplies have been rather strictly controlled, with the result that production of such articles as umbrella handles, fancy toys, fountain pens, has had to be stopped altogether. Cellulose acetate molding powders were put under control by a recent order (for the purposes of the order, the powders are deemed to include any off-cuts or scrap pieces of plastics materials made from cellulose acetate from which articles are subsequently produced by injection or compression molding). So strict is the control that a license granted covering the manufacture of a specific number of articles only covers consumption of molding powders (including that derived from rejects and from runners, sprue or flash produced during the course of molding and normally reworked during the run) up to the total number of articles stated on application, and a fresh license has to be got for the slightest excess. For some of the newer synthetic materials such as polyisobutylene, polyvinyl acetate, polyvinyl acetal and the polyvinyl-chloride basic resins we have had to rely mostly on American and Canadian imports, but there has been an encouraging development of home manufacture of polystyrene, polyvinyl chloride, polyethylene, etc. Finally it is to be noted that there have been some valuable imports of molding plant equipment, though certain parts, such as pumps, machine-tools, etc., are sometimes in short supply.

Administration

Particularly notable has been the increase in influence of the British Plastics Federation. This body has been in constant consultation with the British Standards Institution over questions of standardizing packaging, and has been able to ensure that full consideration is given to containers made of plastics materials, such as soap boxes and shaving soap containers. The Moulders' Section of the Federation has had a special committee conferring with the Plastics Adviser and the Designs Department of the Ministry of Supply on the subject of tolerances on drawings. As a result it is expected that future drawings issued by the Ministry will take more accurate account of limitations in plastics manufacture. The Post-War Planning Committee of the Federation has put forward a resolution to the Board of Trade and other Government departments, covering the disposal of surplus stocks and plants at the end of the war. The Federation is cooperating closely with the Federation of British Industries and the British Electrical and Allied Manufacturers' Association on the question of post-war planning. In this field, Kenneth M. Chance, president of the Institute of the Plastics Industry, has been very active, as he has also been in the work of planning new courses and pupil apprenticeships for attracting young people into plastics in the post-war era. On the Government side, one of the most interesting developments has been the instigation, by the Ministry of Labour, of a series of training classes in mold making, either machining or toolmaking. It is realized that the shortness of the training period (2 or 3 months at the most) limits the capacity of trainees, but experience is showing that even semi-skilled men can free skilled men for more useful work by taking on such jobs as repairs of molds, dismantling and assembling of various molds, etc.

Trends

There have recently been a number of interesting trends in the use of plastics. Perhaps the most interesting has been that of plastics application in the building industry. In addition to the experiment of building an all-plastics house (in Scotland) the British Ministry of Works and Buildings has recently sponsored production of an economy hostel in which plywood (especially resin-bonded plywood) is used to the almost complete exclusion of ordinary timber. Walls, roof, doors and furniture fittings are all of plywood on a light timber frame. They are made on sections at factories and the prefabricated parts are transported to the site and erected in a few hours on a cement base previously laid down. The specimen hostel is 72 ft. by 18 ft. 6 in. by 7 ft. 2 in. (height to the eaves) with cubicles for 24 agricultural or munitions workers. Cubicles are arranged 12 a side. Walls and roof sections are faced on the exposed side with resin-bonded ply. Ministry of Works tests have proved that $^1/_4$-in. resin-bonded plywood can do the work of $1^1/_4$-in. solid timber. Another wartime trend has been research into possibility of substituting plastics for certain uses of leather. This research has been stimulated by the fact of our loss of imports of hides and skins from Eastern sources. It is expected that the shoe industry will have to be granted a priority of plastic supplies to make up for this deficiency. One recent experiment that may show success concerns production of a waterproof sole, using urea-formaldehyde resins.

New developments

These can be cataloged as follows:

Carbide. Considerable progress has been made with schemes for establishing a British carbide industry, and already one fairly large plant is reported to be operating. Britain is not nearly so favorably placed, geographically or from the point of view of natural resources, as some of the Continental countries, particularly Germany. Very large subsidizing would be necessary to build up a successful carbide industry; but now, following losses of Norway, Malaya, Dutch East Indies and other sources of carbide supply, it is realized that cost cannot alone be allowed to count.

Cellulose fiber. Production is reported of a new cellulose fiber, which can be made into rayon by a process which follows the manufacture of viscose in many ways. The process involves the treatment of the orange colored half-stage material (created in process of making viscose) with aniline and sodium chloracetate. This is dissolved in soda, and spun into an acid bath. Unlike viscose, however, the new fiber is not regenerated cellulose, but now contains sulfur and nitrogen, (*Please turn to page 108*)

thus having a greater affinity for acid dyes. Process has been invented by a Britisher, C. Diamond.

Rosin. The Hercules Co. has produced a modification of abietic acid, a rosin in which 40 percent of the unsaturated resin acids in rosin are polymerized, the remainder being unchanged. With a melting point of 100° C. (20° C. higher than that of rosin) the new rosin can be used to make hard ester gums, modified phenolics, resinates and other rosin products. It does not crystallize and has a lower acid value than ordinary rosin.

Plasticizers. It has been discovered that esters of phenols can be used with success as plasticizers for polyvinyl compounds. Phenyl stearate, cresyl stearate, xylenyl stearate and tetrahydronaphthyloleate give particularly good results.

Urea resins. An Erith firm, Albert Products, Ltd., has developed a new method of making urea resins with solubility properties necessary for their use in coating compositions (British Patent 517,196). This starts with the usual commercial 30 percent formaldehyde solution and produces practically water-free varnishes ready for immediate use, with no need for distillation or preliminary separation of the resin.

Drying synthetic powders. As a means of shortening drying time and so reducing costs and danger of fusion of particles, Portland Plastics Ltd. has made use of a new type of highly porous ceramic material, in the form of a thin sheet, 2 mm. thick, suitably fitted into a rebated wooden frame, and spread over with synthetic resin (wholly enclosed in an electrically heated oven, though air was admitted through cloth to exclude contamination from dust). This method showed a reduction of one-third in rate of drying compared to the ordinary metal tray method.

Transparent products. Runcolite, Ltd., has brought out a series of transparent models of engineering gears and parts, machined from cast phenolic resins. These offer great possibilities for engineering research work, and further development of this technique is expected after the war.

Plastics tools. It may be of interest to note that British firms are now making extensive use of plastics tools made of Colmonoy alloys. (*Mailed June 24, 1942, by Denys Val Baker.*)

Boats for the Army

(*Continued from page 45*) are not coated, but simply placed on either side of the assembly and the whole bonded together by means of heat and pressure. The resin bond only partially penetrates the faces.

In impregnated plywood, on the other hand, the faces are thoroughly impregnated with phenolic resin by a variety of methods dictated by the species of wood, its density and the thickness of the plies. The resin penetrates into the interstices between the cells of the wood and covers the cell walls with a waterproof coating, thus increasing the dimensional stability of the wood itself.

As the phenolic resin used for impregnating the wood is in a solution—called a water-soluble resin—it is necessary to remove the water before pressing the veneers together. Otherwise, when they are placed in a hot press, steam will be generated and a blister may result. Such drying must be done at a temperature sufficiently low that the resin itself will not be set or cured. To form the tunnel stern hulls, the phenolic resin-impregnated faces, with the 5 inner plies between them, are placed course by course over a form or mandrel, bound into place, and molded together by the Vidal process.

The advantages accruing to this type of hull construction are many. Since the cellular structure of the wood is literally locked into position and set by the impregnation and curing of the resin, atmospheric conditions, water fungus, and other elements can have very little effect upon it. The dimensional change of resin-bonded plywood from oven dry to saturation is 0.67 percent (perpendicular to face grain), while that of impregnated plywood is 0.167 percent. Thus impregnating the wood has reduced its dimensional change by approximately 75 percent.

Peculiarly enough, impregnated plywood, although it will not swell so much as natural wood, will expand slightly on getting wet—but it will never shrink. In boat construction this is an excellent attribute, although in some applications, naturally, it might not be so desirable. However, adequate protection of the surface by various types of coating will tend to eliminate even this slight expansion. Impregnated plywood is said to have greater resistance to abrasion, greater tensile strength, and to be more fire-retardent than other forms of resin-bonded plywood. It has been found to be proof against marine growth and marine borers. Although the impregnating method makes the outer layers of boat hulls a little heavier, the very strength of this plywood enables the builder to eliminate some structural members and framework, and thereby compensates for its slightly increased weight.

In view of the existing shortages of metals, this newly developed plywood, which can be formed like sheet materials, may be called upon to meet diversified military assignments. And its possibilities in the post-war reconstruction period will depend upon the ingenuity and imagination of the builders of the peacetime world.

Credits—Material: Durez phenolic resin; Impreg Weldwood, by United States Plywood Corp., molders of the hull.

The office record speaks

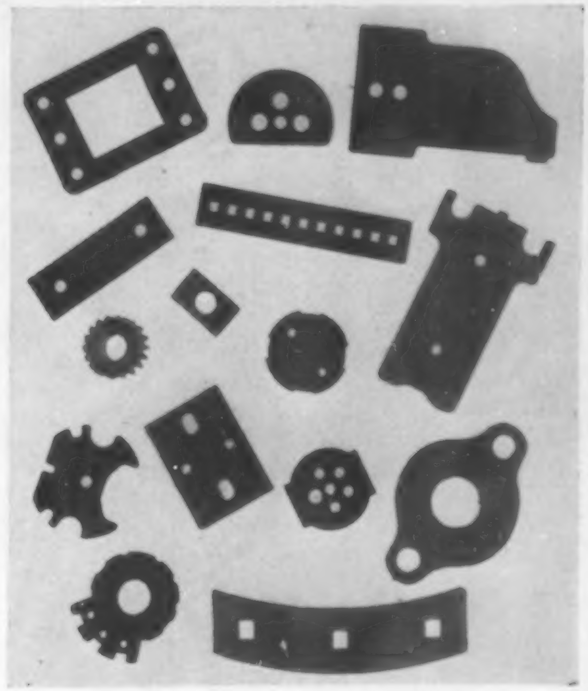
(*Continued from page 59*) of surface noise because the plastic is said to have a lower noise level than the materials previously employed. The stability of the material makes the finished disk impervious to normal temperature and moisture changes so that it can be stored with safety, either before or after the recording has been made. Another advantage is inherent in the stability of the material, which permits as many as 100 playbacks from recorded surfaces. These disks can be handled and filed with ease, and mailed at letter postage rates.

On the receiving end of the recording machine, plastic materials are featured again. The listening device, built on the "acoustic baffle" principle, is a lightweight cellulose acetate and steel band (Fig. 3) which slips over the head of the transcriber or listener. The smooth plastic surface and absence of joints are factors which add to the efficiency of the user because they make for a comfortable, easy-to-wear unit. Two buttons are affixed to the ends of the plastic band to carry the sound from the playback machine to the ears of the listener.

To play the shallow sound tracks with proper tracking and without excessive wear, a moving coil pickup is employed. A light coil frame is mounted on an acrylic frame mounted in neoprene and moving in very heavy oil. The result is described as a very flexible pickup mounting with extremely low inertia, and a minimum wear on records, together with excellent tracking even at pressure less than an ounce.

The simple microphonic method of picking up spoken words makes the mechanism suitable for individual dictation, conferences, radio and all types of recording. During conferences, conversations up to 20 ft. away may be picked up clearly, and the plastic disk makes an instantaneous verbatim record of the proceedings.

Credits—Material: Vinylite; Fibestos; Lucite. Manufactured by SoundScriber Corp.



Strength of plastic plywood

(Continued from page 79)

Δ_{PP} = strain of panel in direction of loading
Δ_{PT} = strain of panel perpendicular to loading
A = strain of longitudinal veneers perpendicular to direction of loading if unrestrained
B = strain of transverse veneers perpendicular to direction of loading if unrestrained

Considering first a three-ply panel (see Fig. 10)

$$A = \frac{\mu_L f_L}{E_L}; \quad B = \frac{\mu_T f_T}{E_T}$$

$$\Delta_{PT} - B = \Delta_{LI}$$

$$A - \Delta_{PT} = \Delta_{TI}$$

Forces must be equal

$$XE_T(A - \Delta_{PT}) = YE_L(\Delta_{PT} - B) \tag{20}$$

$$XE_TA - XE_T\Delta_{PT} = YE_L\Delta_{PT} - YE_LB \tag{21}$$

$$\Delta_{PT} = \frac{XE_TA + YE_LB}{YE_L + XE_T} \tag{22}$$

$$\Delta_{PT} = \frac{X\mu_L f_L \frac{E_T}{E_L} + Y\mu_T \frac{E_L}{E_T} f_T}{YE_L + XE_T} \tag{23}$$

but by Maxwell's theorem

$$\frac{\mu_L}{E_L} = \frac{\mu_T}{E_T}$$

$$\Delta_{PT} = \frac{\mu_L f_L \frac{E_T}{E_L}}{YE_L + XE_T} \tag{24}$$

$$\Delta_{PP} = \frac{Xf_L + Yf_T}{100E_{PP}}$$

$$YE_L + XE_T = 100E_{PT}$$

and $X + Y = 100$

solving

$$\mu_P = \frac{100\mu_L \frac{E_T}{E_L} E_{PP}}{\left(X + Y\frac{E_T}{E_L}\right) E_{PT}} \tag{25}$$

This proof is again based on the assumption that the panel is composed of veneers of the same species throughout; and, as before, if dissimilar veneers are used, a correction factor depending upon the ratio of the moduli of elasticity of the two materials must be introduced.

Knowing the bending modulus of elasticity of the panel and the value of Poisson's ratio, it is felt that the shear modulus may be calculated from the formula found in any standard text on strength of materials

$$G = \frac{E}{2(1 + \mu)} \tag{26}$$

Using this relationship and basic values of μ_L obtained from Jenkins' report,[6] the value of modulus of rigidity of a three-ply spruce panel checks fairly accurately with values suggested in ANC-5.[5]

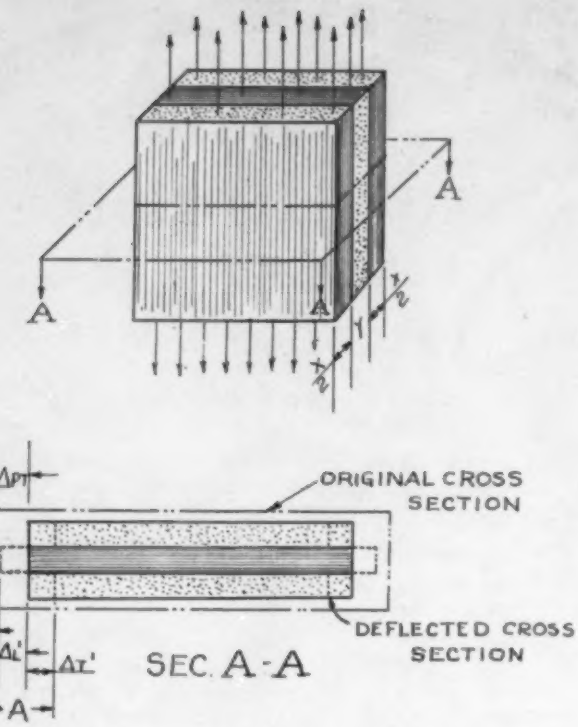


Fig. 10

Concentrated loads on plywood panels

Probably the main disadvantage up to this time in wooden structures for aircraft use has been the question of attaching fittings which involve high concentrations at the point of attachment. An excellent example is the connection required to attach an outer panel or a complete wing to a center section panel or fuselage. The magnitude of the loads involved has necessitated a large number of bolts spread out over a considerable distance because of the low bearing value of bolts in wood. The introduction of these bolt holes has greatly reduced the efficiency of the wood at this point and the bolts required have greatly increased the weight of the construction.

The idea suggested by the Forest Products Laboratory of introducing compregnated wood at these critical sections seemed a practical solution. This process requires the impregnation of wood locally with a urea formaldehyde solution and the application of rather high pressures to obtain a very dense material. This product then has very high bearing values and is unaffected by moisture content changes. The difficulties encountered thus far in the application of this process have been the high pressures required and the control of the amount of impregnation.

With the development of a new adhesive capable of gluing metal to metal or metal to wood, this problem of local concentrations seems to have been solved. One of the beauties of this new adhesive is the fact that it requires the same cycle as presently used in the bag molding process, making it possible to introduce locally a plate having high bearing strength sandwiched between the veneers of the panel. Tests run on this adhesive have given almost unbelievable results. At room temperature a shear allowable of 2000 p.s.i. and a tension value of 1000 p.s.i. are very conservative.

The trend in the plastic-bonded plywood field has been toward true monocoque construction requiring the shell to carry all loads. In such a construction, the introduction of necessary access holes and cut-outs for such items as landing

10—Plastic-bonded panels of various types of construction are carefully tested for tensile and compressive strength. Note construction of a rigid door of this material

lights causes concentration of stresses around these sections, which concentrations are far more critical than in the conventional skin stringer construction. The use of this new glue makes it possible to introduce into the panel around these holes a plate of aluminum or some other material to act as a doubler plate. These plates can be placed in position during the lay-up of the panel and the necessary holes cut through later. The only requirement evident at present is that the plate introduced should have the edges tapered gradually so that a not too abrupt change in section is obtained.

If the metal plate is placed on the centerline of the plywood panel, or if two plates are glued at similar distances from the centerline so that balanced construction remains, there will be no warping evidenced. However, if a metal plate be glued to one side of a panel, the moment introduced by the difference in thermal contractions upon cooling of the panel and plate and the radius of curvature of the warping can be calculated quite easily if the coefficients of expansion of the materials are known.

Conclusion

The author has prepared Table II to compare the basic strength values of plastic-bonded plywood with those of other materials popular in aircraft manufacture. The table is based on unit width of material and so arranged that the specific gravity multiplied by the thickness remains a constant. At first glance it appears that plywood is quite far down the list in strength characteristics, but this is not necessarily the case. In aircraft construction the design criterion is usually one of buckling which is dependent upon the EI or stiffness value of the panel under consideration. It is because of this buckling phenomenon that in thin metal construction stringers and stiffeners must be added throughout to increase the effective width of sheet capable of carrying compressive loads. Although this addition of stringers and stiffeners strengthens the sheet and makes it capable of carrying the load applied, anyone who has ever done any flying will vouch for the fact that wrinkles are still very much in evidence. To avoid these wrinkles, which are evidentaly harmful to airfoil shapes and laminar flow characteristics, requires a construction in thin metal which is heavy, costly and quite impractical. Plywood, on the other hand, having such a high value of stiffness factor EI and allowing the use of a much thicker section, has no tendency toward wrinkling and can with comparative ease be designed to prevent buckling from occurring. It has been demonstrated in a series of tests conducted by the Duramold Aircraft Corp. that plywood has the ability to carry appreciable loads after buckling; and since all airplanes are designed to carry a 50 percent overload, it is possible to design plywood wings to avoid buckling up to the loading of any normal flight condition and to allow buckling to occur safely above this load. This factor, combined with the fact that there are

TABLE II.—RELATIVE STRENGTHS OF VARIOUS MATERIALS

Material	*Specific gravity*	*Thickness*	*Tensile strength*	*Block compressive strength*	*Shear strength*	*EI*
		in.	*lbs./in. of width*	*lbs./in. of width*	*lbs./in. of width*	
24 ST aluminum alloy	2.77	.052	3200	3200	1924	120.7
24 SRT aluminum alloy	2.77	.052	3380	3380	2030	120.7
1025 steel	7.85	.019	1045	1045	665	16.0
4130 steel	7.85	.019	1810	1810	1045	16.6
Magnesium alloy	1.80	.080	2560	2560	1530	277.3
Spruce	.40	.358	3650	2010	412	5230.0
Plywood[1]						
Birch face, poplar core	.66	.205	1918	1304	460[2]	1488.6
Mahogany face, poplar core	.58	.247	1738	956	550[2]	1598.4

[1] The plywood panels were constructed of birch and African mahogany face veneers of 1/20-in. thickness and longitudinal grain direction, and having cores of 5 and 7 yellow poplar veneers, respectively, of 1/48-in. thickness between the faces. These poplar cores had the outside veneer longitudinal and the successive veneers with grain directions at right angles.

[2] Estimated.

no rivet heads or skin laps to interfere with airflow, greatly enhances its application in high-speed airplanes. Since the elastic limit is very near the ultimate in wood the advantage of having elastic deformation for any normal flight loads is apparent.

Contrary to public opinion, plywood fabricated with the resinous products used today has a greater resistance to fire than has an equal weight aluminum alloy part. This is especially true when in the presence of flaming oil or gasoline. The added advantage of having bullets leave clean holes in plywood and the ability to repair such holes with ease make this material especially attractive in the present crisis.

These are but a few of the many advantages of this material. Designers are today thinking of its application as a substitute for the now precious metals, but are discovering in its application the many advantages to be obtained from its low cost, ease of fabrication and good strength characteristics.

It is firmly believed that with gluing technique advancing at so rapid a pace it will not be in the too distant future that the application of a thin metal covering glued to a plywood core will evidence itself in airplanes having extremely high wing loadings. This construction—long a dream of aircraft designers—will combine the high axial strengths of the metal with the good buckling characteristics of the thicker plywood constructions.

Creep tests on acetate

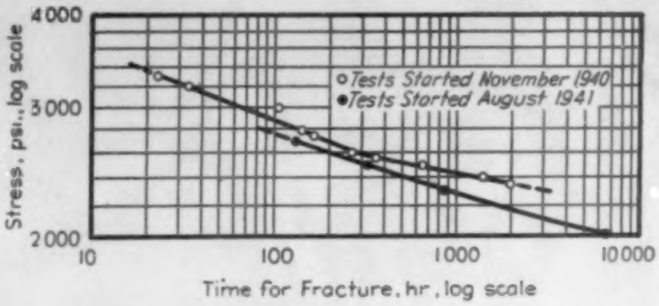
(Continued from page 73) be seen that there is a critical value of stress at about 1500 p.s.i. below which the creep is relatively small and above which the creep is relatively large.

If it be assumed for purposes of analysis that a creep of 1 percent in a time of 6000 hr. (about 8 months) is the limiting value above which structural damage may be said to occur for plastics, then a creep limit may be defined. It would be the maximum stress that can be continuously applied at a constant temperature and relative humidity for a period of 6000 hr. without causing creep of more than 1 percent. Under this definition the creep limit for the cellulose acetate as obtained from the first group of tests is 1000 p.s.i. at 77° F. and 50 percent relative humidity.

Since a practical creep limit has not yet been defined for plastics, the above value is by way of illustration only. It seems likely that different definitions of creep limit will be necessary for plastics used in different classes of service.

Effect of time: The effect of time of loading on the stress which would cause fracture to take place is shown in Fig. 7. In this figure stress is plotted against the time required to cause fracture at the particular stress. Double logarithmic plotting is used. The open circles represent the data for long-time fracture tests started in November 1940 and reported in the previous paper. The filled circles represent data taken from the creep tests shown in Fig. 3. The latter tests were started August 1941. An examination of Fig. 7 shows that the time for fracture is much less for the 1941 tests than for the 1940 tests. For example at a stress of 2400 p.s.i. the time for fracture dropped from 1500 to 500 hr.

Thus aging has reduced the time for fracture at a given stress but aging, as shown above, also decreases the rate of creep at a given stress. It should, however, be mentioned that the duration of aging was about three times as long for the two sets of fracture tests as for the first two sets of creep tests.



7—The effect of stress on the time for fracture under constant load

Also the aging did not occur over the same period of time for the two groups of tests.

The effect of time of loading on the ductility of the material, as measured by percentage elongation at fracture, may be seen in Fig. 3. The percentage elongation at fracture decreases rapidly at first and then more slowly, as the time for fracture increases. For a 200-hr. test, the percentage elongation at fracture was 48 percent. For a 6600-hr. test, the percentage elongation at fracture was 39.5 percent.

Conclusions

The following conclusions may be drawn from the creep tests of cellulose acetate as obtained from tests extending over 10 months' time at a constant temperature of 77° F. and relative humidity of 50 percent.

1. Two regions of constant rate of creep were observed with an initial and an intermediate transition region of decreasing rate of creep. No final stage of rapidly increasing rate of creep occurred, such as the "third stage" of creep in metals.

2. The relationship between the stress and the rate of creep in the "first stage" of creep was found to be expressed by an equation of the form $S = 1440r^{0.065}$.

3. A critical value of stress was observed above which relatively large creep occurred and below which relatively small creep occurred.

4. The creep limit of this material was found to be 1000 p.s.i. (for 1 percent creep in 6000 hr.) at 77° F. and 50 percent relative humidity.

5. The ductility, as measured by percentage elongation at fracture, was found to decrease with increasing time for fracture (or decreasing values of stress).

6. Aging, a change in mechanical properties of materials with time, was observed. For the cellulose acetate tested, aging caused a marked decrease in the first-stage rate of creep. It was also observed, by comparison with previously reported data, that the time for fracture under a constant load decreased with aging of the material.

Acknowledgments: The tests reported are a part of the work of the Engineering Experiment Station of the University of Illinois, M. L. Enger, Director, in the Department of Theoretical and Applied Mechanics of which F. B. Seely is head.

Acknowledgment is made to H. F. Moore and F. B. Seely for their criticism and suggestions during the preparation of this paper and to O. Hintz and R. V. Chase, student test assistants, for their careful work during the conduct of the tests. The author is also indebted to the Plastics Division of Monsanto Chemical Co. for the material supplied, and to the U. S. Regional Soybean Laboratory at the University of Illinois for the loan of certain equipment.

Rugged and resilient

(*Continued from page 44*) and used to seal and protect delicate tubing and threads in aircraft construction. The caps are molded by compression from sheet stock in a 120-cavity mold, come in different sizes to fit various standard tubing sizes and merely slip on over the end, where their rubber-like grip holds them tightly in place. Thus protected, tubing may be handled with speed during assembly operations. Threads are not damaged as tubing is pulled into place. Furthermore, the little caps keep the inside of the tubing free from dirt and dust until connections are made. They work equally well on rigid or flexible tubing and are reported to be replacing rubber caps because of their longer life.

Tubing is almost always coated with a thin film of grease or oil which gradually destroys the life and usefulness of rubber but has no effect on the plastic caps. They can be used over and over again if they are washed in gasoline to remove the grease. Time will somewhat stiffen the material but it doesn't become brittle even at low temperatures, it is claimed.

Credit—Material: Cryst-o-flex. Molder and manufacturer, New Plastics Corp.

Planning postwar uses

(*Continued from page 53*) laboratories have perfected a harder type of transparent material, wipers operating over even a slightly dirty windshield would soon destroy its transparency.

At the present stage, plastics are too expensive and the cycle of production too slow for practical application to automobile bodies. In the transparent, variegated effects that have been suggested by some, there is the problem of cold flow with accompanying dimensional changes and warpage. These characteristics make such material unfeasible for the variety of temperatures to which the modern automobile is subjected. However, much research and experimental work is being done to eliminate these drawbacks, and the practicability of plastics for automobiles may develop overnight. The motor bus would provide the immediate practical proving ground for plastic vehicles. For one thing, mass production is not essential, and lightness in weight would make for more economical operation. Air conditioning is practical for a bus and maintenance is a routine matter. The use of transparent plastics in place of glass would make for both greater safety and greater enjoyment for the passengers.

Figure 3 shows a bus designed to incorporate plastics. The driver sits above in a plastic-encased turret and enjoys unobstructed vision on three sides. At a lower level, an observation area is developed for the passengers. To give each passenger a clear view of buildings and scenery, the observation windows go completely around the bus and extend up into the roof, and the vertical structural members of the body are set back from the windows as in modern architecture. Translucent plastics on the interior provide for shading against excessive sunlight for both driver and passengers. The seats are covered with woven extruded plastic and the lighting is diffused through plastic fixtures. Space for toilets and a canteen is available under the driver's turret.

Resin-impregnated plywood is another material that is currently being widely developed. By use of relatively simple equipment inexpensive plywood can be molded into forms well adapted to airplane construction, boats and furniture. It is the latter field that has opened a host of possibilities in new functional forms to the designer. This material retains the traditional textural beauty and warmth of wood, which tubular steel furniture lacked, and yet allows for new forms that are modern and expressive.

However, if plywood furniture has met public acceptance it is logical to carry the process still further and actually mold plastic furniture. This we feel is the real mass-production solution in this field. In the chairs illustrated (Fig. 4), all assembly has been eliminated except for fastening the transparent plastic legs onto the body of the chair. The body of the chair can be molded by a large press in one piece without undercuts of any kind. It is designed so that it gives support to the body at every point, eliminating the need for clumsy steel springs and substituting a soft sanitary cushion of sponge rubber with just enough yield to prevent fatigue. A zipper arrangement completely around the rim of the plastic body would provide for the lightning assembly of the preformed upholstery fabric. The zipper would draw it down to a perfect fit without the time consuming adjustments required by present methods. Woven extruded plastic might be used for the upholstery fabric. This feature would earn the unending thanks of the housewife who could remove it for cleaning in a split second. The transparent plastic legs are, of course, decorative and would give the illusion of sitting literally unsupported in space. These gleaming black plastic functional shapes should serve as pleasing accents in a modern interior where bright fabrics and light tones predominate.

Housing is still another field in which plastics will have a large part. The use of prefabricated housing during the war period will provide the groundwork and experience for inexpensive and rational post-war housing. This can be realized on a large scale compatible with America's mass production facilities now that the prejudices against prefabrication are being dispelled. In fact, prefabricated factory-built homes are thought by many to be America's great new industry—the one that has the greatest promise of carrying us through the postwar period of readjustment. Architects and designers are agreed that the problem is to reduce the house to the minimum number of integral units. Floor, wall and ceiling panels are already being designed in plastic-impregnated plywood with special insulation sandwiched between the wood veneers.

The utility unit, containing as it does all the plumbing, heating, refrigeration, cooking and cabinet facilities, would be the core of this new conception of the house and here plastics would have a dominant rôle. In fact, entire bathroom and kitchen walls could be molded with integral fixtures—a practical idea in view of molding technique now being developed. The material could be of the porous resin-impregnated type, preformed by vacuum methods which have been suggested above for refrigerator application. In this case, the refrigerator as well as the sink, stove, bathroom lavatory, tub and toilet would actually be molded as part of a wall panel. All plumbing, electrical wiring and heating would come through a main duct which could be directly connected to outside service lines. This impregnated material would also be desirable for exterior walls, since it has the requisite insulation qualities and a permanent exterior and interior finish. Interlocking joints, door and window jambs could be molded right in the panel. Plastics will play a great part in the decorative trim, particularly in lighting where its mellow diffusing qualities are a perfect solution.

Because of the interchangeability of the units, houses will not be standardized but can be built in various sizes and according to plans which meet the requirements of the indi-

vidual. A community of these houses will have a great deal more harmony and interest because of the repetition of the same size design elements than have our present neighborhoods with their conscious monotonous striving to avoid monotony.

All these possibilities provide vast horizons for design and research and it should be the rôle of the designer to envision, explore and promote these new applications. To avoid any conflict with the war effort, much of the preliminary work can be handled immediately by the designers themselves. They can survey markets, chart consumer preferences and make concrete suggestions for future products.

Airplane pilot seats

(***Continued from page 49***) considerably over-strength when subjected to static loads. For this reason, subsequent seats were manufactured lighter and with lighter detailed parts. However, a seat made of the plywood is roughly $4^1/_3$ times as thick as a metal seat of equivalent strength and rigidity.

In the company's laboratory, a 2400-lb. test was applied to the finished pilot seat because 170 lb. is the standard weight for a pilot, who carries strapped to him a 30-lb. parachute and gear, and has to be seated in a seat of sufficient strength to withstand a 10-G pull-out. When the original seat normal load requirements of 2400 lb. were laid out in lead pigs stacked on the seat no indication of stress appeared, according to the report. Since no additional lead was available at the time, various pieces of cast iron were added until the seat could hold no more. When the seat still showed no evidence of stress, the cast iron was removed and 225 lb. of workman climbed on top of the load, and jumped up and down in a determined effort to cause failure. Even under this punishment, we are told, the seat held fast and the assault did no damage.

The bucket seat is constructed so that a parachute pack fits exactly into the bottom of it, forming a sort of cushion

6—***Lightweight, weatherproof and durable, this molded plastic plywood pilot seat is an experimental model for trainers***

PHOTO COURTESY VIDAL RESEARCH CORP.

for the pilot to sit on. Although these seats are not yet on a production line basis, it is estimated that they can be made as economically as metal.

A third type of material employed for a non-metal pilot seat (Figs. 3-4) is a canvas fabric especially woven for high tensile strength, and impregnated with a modified phenolic laminating varnish. This material is laminated into a single rigid piece in a specially designed mold. In molding, the surface temperature is maintained at 340° F. throughout, and the pressure at approximately 3000 lb. per sq. in.

This laminated seat, it is reported, has been approved by the Air Corps for standard installation in all types of planes with the exception of the long-range bomber, which requires a special upholstered seat. This seat has been subjected to, and has passed, several field tests, and is now in production on a regular assembly line. Most of the seats in manufacture and scheduled for production within the next few months are intended for America's best fighting planes.

Tests conducted are reported to demonstrate clearly that the strength-weight ratio of these modern plastic-bonded plane seats is not only completely comparable to that of the metal, but that they have many advantages in construction and inherent properties which ensure their continued use long after the present emergency shall have been resolved.

Credits—Manufacturer and material used respectively: Fletcher Aircraft, Plaskon urea-formaldehyde glue. Capac Manufacturing Co., Catalin. Vidal Research Corp., Plaskon urea resin.

A career in plastics

(***Continued from page 63***) polymerization studies, testing of plastics, lamination and molding. This course is given during the fall term.

John Carroll University in Cleveland, Ohio, offers two courses in plastics, one covering the theoretical aspect of the subject and the other the technical and industrial side. The various methods of molding and fabricating a variety of plastics are discussed and illustrated, the chemical and physical properties of plastics determined. Laboratory facilities are available.

A comprehensive course in plastics technology is being offered at the *Case School of Applied Science*, in Cleveland, Ohio. A well-equipped laboratory contains necessary apparatus for the preparation of synthetic resins, their incorporation with fillers, plasticizers, lubricants and dyes; compression and injection molding equipment. High-pressure equipment applicable to the study of high-pressure reactions up to 20,000 p.s.i. and the usual glass-lined reactors and ordinary laboratory glassware are also available. A ball mixer, a differential speed roll mill, and a Schiller-type mixer are provided for incorporation of fillers, plasticizers and dyes. A $1^1/_2$ cu. ft. vacuum drying oven and a 3 cu. ft. infrared ray oven are also available. A miller, a small laboratory press, a 2-oz. vertical injection molding machine and a 100-ton compression molding press are also available.

At *Virginia Polytechnic Institute*, in Blacksburg, two courses are offered, one on the chemistry of plastics, and the other on the technology of plastics. Among the equipment at the Institute are a vacuum-batch still used in phenol-formaldehyde plastic production, a revolving pan mixer for mixing filler for plastics, three small gallon to two-gallon autoclaves in aluminum or cast iron, a laboratory molding press, a three-roll differential compounding machine and an

annealing oven in which temperatures can be held as high as 250° C.

In Montreal, Canada, *McGill University* offers three courses on plastics chemistry and technology: a short course for undergraduate chemical engineers and honor chemistry students; a comprehensive course for graduate students; a comprehensive course offered by the extension department to chemists and technical sales representatives. Theory and practice of plastic materials and synthesis are treated and laboratory and library facilities are available.

In many colleges and universities where the study of plastics is not accorded independent treatment or specialized courses, the subject is included, and frequently treated in considerable detail, in courses such as chemical engineering, design, industrial chemistry, defense training, materials of constructions, etc. Among the institutions which include a consideration of plastics as part of another course are: *University of California*, Berkeley; *University of Denver*, Colo.; *Colorado State College*, Fort Collins; *State Trade School*, Stamford, Conn.; *University of Florida*, Gainesville; *University of Illinois*, Chicago; *Lake Forest Academy*, Lake Forest, Ill.; *University of Illinois*, Urbana; *Iowa State College*, Ames; *Kansas State College*, Manhattan; *University of Maine*, Orono; *Massachusetts Institute of Technology*, Cambridge; *Lawrence Institute of Technology, Detroit, Mich.*; *University of Minnesota*, Minneapolis; *Missouri School of Mines and Metallurgy*, Rolla; *University of New Hampshire*, Durham; *State Teachers College*, Buffalo, N. Y.; *College of Engineering*, Cornell University, Ithaca, N. Y.; *University of Cincinnati*, Cincinnati, Ohio; *Lehigh University*, Bethlehem, Penna.; *Bucknell University*, Lewisburg, Penna.; *Philadelphia College of Pharmacy and Science*, Philadelphia, Penna.; and *University of Virginia*, Charlottesville.

Further information on courses given at all schools and colleges mentioned may be procured by applying directly to the schools themselves.

Laminated plastic pipe

(Continued from page 58)

Wet chlorine gas, used in the bleaching process in the manufacture of cigarette paper, is handled by plastic pipe at 70 lb. pressure. A real problem was solved in this set-up by shutting off the flow with the valve shown in Fig. 1, which prevents the chlorine gas from coming in contact with metal. Laminated plastic replaced silica bronze piping in the handling of kaolin clay solutions on a clay filter press. Due to the acid and various chemicals in the clay, metal pipe soon deteriorates. The plastic pipe, which takes the water out of the filter, has a life two to three times longer than the best (3 to 5 months) life of the bronze pipe.

Another application is in connection with a bleachery where sulphuric acid is piped from the storage tank to the processing machines in the bleachery. The solution, approximately 10 to 15 percent acid and at room temperature, is mixed in the storage tank and flows by gravity through the phenolic pipes to the processing machines. Further experiments are in process for piping mine water from a coal mine. Here the problem is to reduce or eliminate corrosion by replacing metal pipe with piping of the laminated-phenolic.

Credits—Material: Micarta, by Micarta Div., Westinghouse Electric and Mfg. Co.

Parachute flare base

(Continued from page 57) temperature is maintained at 115° until the process is completed. The individual flare base blocks are then machined from the flat lamination with a rotary saw employed as the major cutting implement, and routing tool, drill and finishing lathe used to achieve the smooth, flat finish in the final operation.

The main suspension by which the base is attached to the parachute is furnished by a woven or twisted wire cable with a tensile strength of 2000 lb., anchored firmly to the base block which must be capable of maintaining equal strength. Anchorage is effected by a drilled hole in the center of the base block and a radius section grooved for the cable which is wrapped around it and anchored by means of a large knot or any other type of obstruction which exceeds the dimensions of the drilled hole so that it will not pull out under any circumstance.

This laminated structure represents a replacement significant not only for the obvious and important reason that it conserves precious aluminum, but the base itself is practically non-flammable and is described as having the good machinability and hardness properties of the hardest wood and steel.

Credits—Material: Tego resin film, Resinous Products & Chemical Co. Manufacturer of the flare: Armstrong Cork Co.

Miniature industrial process

(Continued from page 54) bottom of the laminated panel are 4-in. by 5-in. Kodachrome transparencies—photographs of specific pieces of equipment and samples of materials, arranged in chronological production sequence to maintain the continuity of the flow diagram. These light up one by one, as the section under consideration corresponding to the operation depicted becomes illuminated. Across the top of the chart is a panel of samples of the various materials used in the process, each sample contained in a 25 mm. Erlenmeyer flask which simulates the appearance of distillery stock bins.

The lighting system which comprises 16 complete circuits is controlled by a series of cams activating micro switches. They are arranged on a central shaft driven by a constant speed AC-DC motor, which is geared to a shaft requiring seven minutes for a complete revolution. Seven minutes is the time required for a full cycle showing the process in its entirety. There are approximately 500 ft. of wiring on the back of the panel, necessary for the 16 circuits required to show each operation in the process. When the entire 16 circuits have completed their individual illuminated chapters, the whole panel lights up and remains illuminated in a grand finale which lasts about two minutes before the cycle begins again.

A larger model, just twice the dimensions of the original, reported to be in the process of construction, will serve upon completion as a permanent exhibit to complement other industrial displays in the Chemical and Metallurgical Building of Purdue University. The same materials will be used: laminated phenolic with its permanent, high-luster finish, resistance to corrosion, and ease of machinability for the background; and methyl methacrylate for the functional units.

This display, although it was originally designed for engineering students, tells the story of a complex manufacturing process with sufficient clarity and simplicity to be understood by, and helpful to, the lay public.

Credits—Material: Formica; Plexiglas. Manufactured by House of Plastics for Jos. E. Seagram & Sons, Inc.

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Extruding vinylidene chloride

(Continued from page 36)

Extruded and oriented shapes are now commercially available from fabricators of this material located throughout the country. Circular monofilaments are being produced in diameters from .008 to .062 inch. Other shapes having maximum dimensions up to .200 in. may also be obtained. These are characterized by extremely high tensile strengths in comparison with other thermoplastics as in Table I.

TABLE I—TENSILE STRENGTH, BREAKING STRENGTH AND YIELD PER POUND, VINYLIDENE CHLORIDE CIRCULAR MONOFILAMENTS

Nominal size	*Minimum T.S., lb./sq. in.*	*Breaking strength, lb.*	*Yield/lb. ft. approx.*
.012	40,000	4–5	11,000
.020	35,000	12–13	4,000
.030	30,000	25–27	1,800
.050	20,000	60	690

In addition to strength, oriented sections exhibit great toughness and flexural fatigue life. For example, strands .140 in. × .024 in. can be flexed through a 270° arc under a load of 1.5 kilograms 6000 to 9000 times.

Abrasion resistance is of a high order when the heat generated by friction is not sufficiently high to melt the material. This property is of chief importance, however, in applications such as seating fabrics where wear resistance is of great significance. In a scuff test run by one manufacturer of public seating, no change was reported after two weeks of constant rubbing.

One of the outstanding characteristics of the new plastic material is its resistance to chemicals and solvents, and this resistance is greater in the crystallized form than in the amorphous state. At room temperature, it is extremely resistant to acids and common alkalies, except for concentrated ammonium hydroxide. Little change in mechanical properties occurs when the material is exposed for long periods to concentrated sulphuric acid or caustic, although slight discoloration may be noted. It is essentially unaffected by aliphatic or aromatic hydrocarbons, alcohols, esters, ketones and nitro-paraffins. It is swelled or softened only by oxygen-bearing organic solvents such as cyclohexanone and dioxane. Resistance to chemicals or solvents decreases with a rise in temperature.

Extremely low water absorption and moisture vapor transmission are also characteristic of the material, as is its dimensional stability under a wide range of moisture exposure conditions. It ages well.

Still another advantage of the vinylidene chloride filament lies in its appearance. It is reported to be the only plastic extruded into monofilaments of any sizable diameter which are highly colored and of good strength. Fabricators now supply the material in an extensive color range, and new additions are constantly being made. In general these colors are as resistant to sun exposure as the ordinary vat dyes, with some being superior.

Weaving

Vinylidene chloride filaments are adaptable to standard textile operations, and have been fabricated by braiding, weaving, knitting and twisting. Most types of looms may be utilized in weaving this plastic, although the lighter type looms may require some reinforcements. Careful adjustment of loom tensions is necessary, due to the elasticity of the filament. Lubrication to prevent drag is desirable, and care must be taken to avoid excessive friction. It is recommended that plenty of air space be allowed in the weaving reed as the friction of the reed in its back and forth motion has a tendency to roughen the walls of the filament. About 60 percent air space to 40 percent metal is not too much. Best results are obtained when temperatures in the weave room are kept around 70° F.

The fabric when first taken off the loom is porous in weave, stiff, wavy and harsh to the hand. Further finishing operations, however, greatly improve its appearance and feel. Two methods are utilized, depending upon the final characteristics it is desired to achieve in the fabric.

In one, the fabric is run over hot steam cans by conventional textile practice. Under these conditions a slight shrinkage occurs which makes it softer to the touch and the filaments are crimped or formed one to another in the fabric. The results show a striking improvement. Since the degree of shrinkage is directly influenced by the temperature, the process can be controlled to provide the exact finish desired. Temperatures ranging between 72° C. and 82° C. are usually employed. The other finishing method involves pressure calendering operations in which the individual filaments are flattened to form a smooth surfaced fabric. Such materials are especially suited for seating fabrics.

Applications

Both wide and narrow fabrics woven from the monofilaments have found a ready market. Wide fabrics are used for transportation, public and domestic seating (page 39)

Narrow fabrics have found favor with the public as belts, braces and various types of trimmings. Robe rails and assist cords of vinylidene chloride fiber were introduced in the 1942 automobiles and were eagerly received for their decorative value. Tubular braid fabricated into dog leashes has also enjoyed an extensive market. While these applications are at a standstill for the duration, they constitute the basis upon which many postwar markets will be built.

Among the most significant of the new textile developments, however, is insect screen now being put on the market. Fabricated on either wire or fabric looms, the screen can be produced in standard meshes and widths. In addition to easing present shortages of critical metals, the plastic in itself has many advantages for the application. Chief among these should be mentioned its resistance to sulphur fumes present in coal smoke in large cities, salt atmosphere encountered along the sea coasts and alkali present in arid areas. All of these attack metals. In addition, the plastic screen is easily kept clean, does not require painting and is considerably lighter in weight for handling and shipping.

Considerable interest also has been shown in the extruded vinylidene chloride material for special service ropes and cores for wire ropes. Chemical and fungal resistance and high wet strength are the factors of prime consideration here. Not as yet an extensive market, this field has been constantly growing and present shortages of manila fiber are now stimulating new programs of research in this direction.

In addition, vinylidene chloride plastic, because of its unusual properties, is certain to expand broadly the field of thermoplastic applications. These will go far beyond novelties and gadgets and will include many sound industrial uses where this man-made material surpasses in service performance the natural products now used.

Molded ammunition rollers

(Continued from page 41) materials laboratory (extracts from which are given below) showed conclusively that cellulose acetate butyrate can be successfully molded to fill a tough, responsible assignment.

Samples of both rollers were sent by the molder to the laboratory to be tested for final approval before production shipments were made to the company's factories. According to blueprint requirements for these pieces, they were to be made of red cellulose acetate butyrate, with holes in each end concentric with each other and with outside diameters by ±.010 in. All small radii were to be $^1/_8$ in. (except as noted), and component parts were to be permanently sealed. The rollers were called upon to withstand a temperature range of −40° F. to 160° F. without deformity or tendency to breakdown.

The plastic used for the rollers was found by the laboratory to have excellent permanence properties and superior molding qualities and toughness—a cellulose acetate butyrate, injection type, V formula, classified as a second degree plastic.

The plastic roller samples were then tested for conformance to requirements for color, cementing quality and effect upon them of the temperature range. The smaller roller passed all three, but some changes in cementing procedure were made in the larger, or ammunition feed chute roller, as a result of its performance at the −40° temperature test. The molder and the laboratory agreed that the following cementing procedure gave the best results and would be adhered to in production of this roller: the shaft would receive a coat of cement prepared by the manufacturer of the cellulose acetate butyrate for use with his product; the inner diameters of the wheels would get a similar coat and, as they were fastened to the shaft, the latter would be given another coat of the cement. One joint (the outside fillet) between the wheels and the shaft would be sealed by cementing. This method of cementing gave the best results in the hot and cold temperature shattering tests, when the material itself failed before the cementing bond did.

Next, the rollers were given a service test to determine their suitability at extremes of temperature to which they would be subjected in flight. Figure 3 shows the set-up of the rollers (two of each), two aluminum alloy metal rollers and the cartridge belt as the test was conducted for wear or breaking at extreme temperatures. The speed of the cartridge belt was adjusted, and the rollers given four separate tests. Run 1 was at room temperature; Runs 2 and 3 at high and low temperatures, respectively, and Run 4 was an endurance test. After each test run, the rollers were removed from the testing equipment and examined carefully for cracks, splits, and other signs of wear.

As noted before, the smaller roller showed the marks of the cartridge links after the first run and this marking became more pronounced with successive runs. Otherwise, Run 1 showed no defect in either type of roller. Run 2 (160° F.) produced no softening of cement in the large roller, no cracks or other signs of failure in either part. No cracks or chips were evident after Run 3 (−40° F.), and no cold flow resulted. The fourth run (endurance test) showed that the plastic rollers could take it when no signs of breakdown or wear other than the scratches on the small roller were evident when they were removed from the assembly and inspected.

Credits—Material: Tenite II. Molded by Sterling Injection Molding, Inc. Engineers, C. G. Trimbach and P. F. Rossman, Curtiss-Wright Corp.

Because cellulose acetate has proved eminently satisfactory in this application, it may be used for ammunition rollers in additional types of planes in the near future; and a story on other varieties of molded rollers being put in production at present by several molders will appear in an early issue of MODERN PLASTICS.—ED.

MATERIALS LABORATORY (partial report) TEST I

Curtiss-Wright Corp. Airplane Division-Buffalo Plants, Buffalo, N. Y.

Report No. 41-142 Lab. No. 864-1 Date 8-27-41

.50 CALIBRE PLASTIC ROLLERS

Part No. 87-69-526: 87-69-564

— — — — — — —

OBJECT: To determine conformance to B/P requirements of .50 calibre plastic rollers submitted by Sterling Injection Molding, Inc., as production samples for final approval previous to regular production shipments.

BLUE PRINT REQUIREMENTS: *Material—Commercial as noted.*

1—To be molded of cellulose acetate butyrate (Tenite II or equivalent). Color—Red. #13822.

2—Holes in each end to be concentric with each other and with outside diameters of rollers by ±0.010 in.

3—All small radii $^1/_8$" except as noted.

4—All component parts to be permanently cemented together.

5—Temperature range, −40°F to 160°F without deformity or tendency to breakdown.

SAMPLING: 1—Three samples each of Part No. 87-69-564 and Part No. 87-69-526 delivered to Curtiss Receiving Inspection by Mr. Carl Marquardt, President of Sterling Injection Molding, Inc., on August 21, 1941.

2—Three samples of Part No. 87-69-564 delivered to Materials Laboratory August 22, 1941, as improved cemented assemblies.

3—Three samples of Part No. 87-69-564 delivered to Materials Laboratory August 25, 1941, for test of cemented assembly because of large tolerance between shaft and bearing surface of plastic roller.

The Tenite used by Sterling Injection Molding, Inc., complied to the following material specification:

"Tenite II-Tennessee Eastman No. AV-13822-H$_2$."

This indicates that the material is Eastman cellulose acetate butyrate, injection type, V formula, color number 13822 (red) and a hard, second degree plastic.

Stated physical properties of this material are as follows: (Brochure Edition 6B).

Flow temperature	314°F
Hardness Rockwell "M" scale	85
Elongation	27%
Tensile strength	6,300 P.s.i.
Flexural strength	9,700 P.s.i.
Compressive strength	18,900 P.s.i.
Impact strength	Charpy—2.0 ft. lbs.
	Izod—1.6 ft. lbs.
Water absorption (24 hrs. immersion)	1.6% wgt. gained
Accelerated aging	.2% wgt. lost
(1 week at 150°F.)	.1% shrinkage

This formula has excellent permanence properties and superior molding qualities, and toughness. The V formula is the most widely used formula of Tenite II because of its well balanced physical properties.

PROCEDURE: 1—The first submitted samples were tested for conformance to B/P requirements of color, cementing quality, and effect of temperature range of −40°F to 160°F.

2—The three samples Part No. 87-69-564 delivered to the Materials Laboratory for re-check of cemented assemblies were checked to B/P requirements.

3—The three samples Part No. 87-69-564 which were delivered to the Materials Laboratory for checking due to loose fit between shaft and bearing surface of the roller, were checked to B/P requirements.

4—Hardness tests on the "M" Rockwell scale were taken on the samples submitted by Sterling Injection Molding, Inc., and compared to the Tenite II plastic rollers molded by Erie Resistor Co., for similar hardness values.

RESULTS:

Samples	*Color check to standard color Red #13822*	*160°F Temp. 2 hr.*	*−40°F Temp. $^1/_2$ hr.*
1—3 samples			
Part #87-69-526	O.K.	No defects	No defects.
Part #87-68-564	O.K.	O.K.	Cement failed Rejected—poor assembly procedure

(Please turn to page 126)

2—3 samples

Part No. 87-69-564	O.K.	No defects	No defects

As a result of these tests, it was agreed between Materials Laboratory and Mr. C. Marquardt, Sterling Injection Molding, Inc., that since the following cementing procedure gave the best results it would be adhered to in production.

a) The shaft would receive one coat of cement, which is especially prepared by Tennessee Eastman Corp. for use with Tenite II.
b) The two wheels would receive a coat of cement on their inner diameters.
c) The shaft would receive another coat just as the wheels are fastened to the shaft.
d) One joint (the outside fillet) between the wheels and the shaft would be sealed by cementing.

This cementing procedure gave the best results upon hot and cold temperature shattering tests. The plastic material failed before the cemented bond failed.

3—It was found that the prescribed method of cementing was satisfactory for the assemblies submitted with a loose initial fit between the wheel and shaft of the plastic roller and approval was given to Mr. M. Bobier, Receiving Inspection, to have Sterling Injection Molding, Inc., start production shipments.

4—The hardness test results follow:

Rockwell "M" scale.
- 1/4" ball penetrator
- Minor load of 10Kg
- Major load of 100Kg
- Red scale figures on dial
- Major load will be fully applied in 6–8 sec.
- Major load to be removed within one second after the crank handle mechanism has come to a stop.

Part	Vendor	Hardness
#87-69-564	Sterling Injection Molded, Inc.	M 76

Conclusion: The plastic rollers now being molded by Sterling Injection Molding, Inc., are satisfactory for productive use. All requirements of the B/P have been met.

Recommendations: Although the Tenite II used in molding this roller is somewhat similar to that used for the starwheel which passed the service test satisfactorily, a service test similar to that reported in MLR 40–51 involving a temperature range from 160°F to −40°F is recommended since the design of this .50 calibre roller has not been tested in respect to plastic material and actual service conditions.

TEST II

Report No. 41-187 Lab. No. 964-1 Date 11-12-41

.50 CAL. AMMUNITION BOX PLASTIC ROLLERS SERVICE TEST
Part No. 87-69-526; 87-69-564

- - - - - - -

Object: To determine the suitability of .50 cal. ammunition box plastic rollers molded from Tenite II, at extremes of flight temperatures, by means of a service test.

Reference:
1—Materials Laboratory Report #41-51 dated 4-28-41 "Plastic Ammunition Box Roller."
2—Materials Laboratory Report #41-142, dated 8-27-41 ".50 Cal. Plastic Rollers."
3—I.O.M. to E. Dudley from W. O. Watson, dated 9-15-41. Requested service test on plastic rollers.
4—A.V.O. to S. A. Sheridan from E. Dudley, dated 9-18-41. Requested service test on plastic rollers similar to Reference 1.
5—I.O.M. to Hartman from C. Trimbach, dated 10-3-41. Authorizing issuance of 50 rounds of .50 cal. dummy ammunition for service test of plastic rollers.

Sampling: The following samples were secured from Curtiss stock:
1—Two plastic rollers, Part No. 87-69-564, assembled with the insert tube and pinned. This is the larger of the two plastic rollers used.
2—Two plastic rollers, Part No. 87-69-526, assembled with the insert tube and pinned.
3—Two aluminum alloy metal rollers, one of which (No. 1) served as a driver and the other (No. 4) was used as an idler.

Procedure:

Part I

Effect of temperature—aging, on bending

a) Half a plastic roller, Part No. 87-69-526, was halved lengthwise and bent till failure, as-received and at room temperature.
b) Half of a plastic roller, Part No. 87-69-526, was aged at 170°F for two weeks. It was halved lengthwise and bent in a vise till failure. Bending was at room temperature.
c) The other half of the above roller was aged at 20°F for two weeks. It was halved lengthwise and bent in a vise till failure. Bending was at room temperature.

(*Please turn to page 128*)

PART II

Service test to determine wear or breaking at extreme temperatures

A set-up as shown in photograph S-F 15274 which accompanies this report was constructed and is described as follows: [See Fig. 3]

A. *Description of set-up as shown in photograph S-F 15274*

Roller No. 1 (*Alum. alloy*) This roller was the driver. The shaft from the chain belt drive extended through the roller and the motion was transferred to the cartridge belt. The star attachment had to be put on this roller to provide a steady drive of the cartridge belt.

Roller No. 2 *Tenite II* This is a larger size plastic roller Part No. 87-69-564. The assembly consists of two large rollers which have been cemented on the shaft which is described in Reference 2.

Roller No. 3 *Tenite II* This is the smaller size of the two plastic rollers tested. It consists of a shaft as shown in the accompanying photograph S-F 15275 roller No. 3. This roller is installed so that it acts in the same way as in actual service. [See Fig. 4]

Roller No. 4 *Aluminum alloy* This roller served as an idler, that is, the cartridge belt travelled over this roller at a 90° angle contact.

Roller No. 5 *Tenite II* This plastic roller is the same part as roller No. 2 and serves the same function.

Roller No. 6 *Tenite II* This plastic roller is the same part as roller No. 3 and is similar in its function as shown in the photograph.

B. *Testing Program*

Test 1. *Room temperature*

A run at room temperature which corresponded to a 27,000 round run, was made. The cartridge belt was removed and the plastic rollers examined for wear or cracks.

Test 2. *High temperature*

A run at 160°F which consisted of 28,715 rounds equivalent, was made. The heat was supplied by an electrical resistance heater and forced air. The cartridge belt was removed from the set-up and the plastic rollers examined for wear.

Test 3. *Low temperature*

A run was made with the temperature at −40°F. Dry ice and compressed air was used to provide the cold medium. This run was equivalent to 29,000 rounds. After completion, the cartridge belt was removed from the set-up and the plastic rollers were closely examined.

Test 4. *Endurance test*

A continuous run was made at room temperature. This run was equivalent to 236,010 rounds, by actual count. After this final run the set-up was dismantled and the rollers examined for wear.

RESULTS: *PART I—Effect of temperature, aging, on bending*

Bend Test: Radius—Nil. Very Sharp.
a) Room temperature—160° failure
b) 170° temperature—160° failure
c) 20° temperature— 90° failure

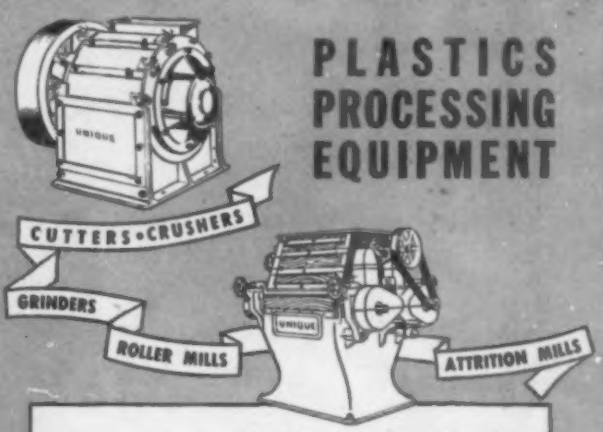
PART II—Service test

Run No. 1—

Room temperature 70°F: 27,000 rounds equivalent. There was very slight wearing of roller No. 3 and 6 where the cartridge links had contacted the plastic roller.

Run No. 2—

High temperature 160°F: 28,715 rounds equivalent. There was no softening of the cement used on the assembly of the large rollers and no cracks or other defects were



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found. There was continued wear on the two plastic rollers No. 3 and 6 due to the cartridge links.

Run No. 3—

Low temperature −40°F: 29,000 rounds equivalent. Examination of the plastic rollers showed no cracks or chips. Rollers No. 2 and 5, the larger size plastic rollers, showed no wear or cold flow. Plastic rollers No. 3 and 6, the smaller size rollers, did show continued wear at the point of contact with the cartridge links.

Run No. 4—Endurance test.

Room temperature: 236,010 rounds equivalent. Examination of the plastic rollers revealed that the smaller size plastic rollers, No. 3 and 6, showed definite signs of wear. This wear can be noted in photograph S-F 15275. This wear can be attributed to the sharp edges of the metal cartridge links. The larger size plastic rollers, No. 2 and 5, showed no evidence of wear or breakdown.

DISCUSSION OF RESULTS: The total number of equivalent rounds run on this test was 320,725 which is the total equivalent rounds of all the runs made. With the exception of the wear noted on the smaller size plastic rollers which did not affect the serviceability of these rollers, the plastic rollers withstood the effects of the service test satisfactorily.

CONCLUSION: As a result of the tests recorded herein, it is concluded that the plastic rollers molded from Tenite II by Sterling Injection Molding Inc. as noted, are suitable for the purpose intended at and between extremes of atmospheric temperature.

Extruded tubing for war

(*Continued from page 56*) controlled. The die-holder should be designed so that interchangeable mandrels and dies may be used. Air under pressure should be fed through the mandrel to keep the tubing round while it cools. Figure 2 shows a phantom view of one method of accomplishing this.

In order to obtain the infinite variety of sizes of tubing which may be required, it is customary to obtain size control by the take-away speed of the conveyor belt and by adjustment of the internal air pressure. Thus the tubing may be drawn away faster than extruded to make a smaller diameter; blown with air to make a larger diameter; or by a combination of both, manipulated to a thin-walled tubing either large or small. There is a maximum free area between mandrel and die which must be established for each size and make of machine operating on each type of thermoplastic. Exceeding this area will decrease the pressure which the screw exerts so that bubbles may form in the tubing wall and so that there is no orifice effect to iron out flow irregularities. Usually a set of about six mandrels and six dies will make a full-size range of tubing. It is difficult to make small runs of a size of tubing because it may take many pounds of material before everything is in adjustment to produce the size required. Conditions taken as data from previous runs are only a general guide, since variations in temperature gradients and variations in plastic stock are unavoidable from time to time, and require a re-establishment of conditions each time the extrusion machine is started. Variations are also found from color to color in the same material because of the effect of the dyes or pigments on the flow characteristics.

To obtain regularity of dimension, it is necessary to have all temperatures controlled to within 5 deg. F. and uniform around the circumference of the die-holder. It is also necessary that the tubing leaving the machine be guarded carefully from drafts or other fluctuating conditions which might affect the rate of drawing or blowing. Careful regulation of air pressure is another requisite. (*Please turn to page 132*)

It is possible to obtain close control over the outside diameter of tubing by use of an external die through which the tubing is drawn while cooling. The air pressure holds the tubing against the wall of the die. This expedient is only satisfactory where uniform outside diameter is more important than inside diameter or wall, since the feeding irregularities are not improved. All dimensional variations take place on the inside diameter and in the wall thickness. The external die is also the most convenient method of producing square, rectangular or multi-sided tubing.

Replacing rubber

(Continued from page 67)

While the replacement of rubber tubing was a major objective of the RCA conservation campaign, it did not stop there. The company was also using rubber for many machine parts of a highly mechanical nature. Experiments with the polyvinyl alcohol compound in the tubing field had revealed that in addition to having high solvent resistance and exceptionally low permeability, this material was extremely tough and stood up under both flexing and abrasion. Engineers of the manufacturing corporation were therefore asked to revamp samples of their sheet stock until a compound was arrived at which conformed to the Durometer index and texture of the rubber normally used. Testing of the alternate material was simplified by the ease with which blocks could be fabricated. Pieces were cut or punched from $^{1}/_{16}$-in. or $^{1}/_{8}$-in. sheet. These were then laminated into washers, spacers, rollers, etc., without the need for any special presses or molding machinery. Rough shapes so formed were machined to required dimensions on standard shop equipment. Some such sections were frozen solid in liquid air or mounted onto wooden blocks to facilitate machining.

In these mechanical applications, involving abrasive action and torsional strains, the polyvinyl alcohol compound has consistently outlasted rubber. A typical instance involves a power transmission device, wherein a revolving turret carries

8—***Another rubber replacement is this aligning ring used for clinching small metal parts on radio tubes***

a series of heads, which in turn are revolved in a sequence of indexed positions. The heads are caused to rotate when their shallow-toothed, metal drive gears are brought into mesh with rings clamped to driven clamps below the turret. The compound has replaced rubber for these power transmission rings (Fig. 7), and is consistently outwearing the former product.

In another case a two-ply tube was formed by rolling $^1/_{16}$-in. sheet about a $^3/_{16}$-in. diameter mandrel. This tube was installed in a sandblast suction line (Fig. 3) where rubber tubing had worn through in a few days. In the same machine shields made of the synthetic resin sheet (Fig. 5) have likewise proved more durable than rubber, while it has also been possible to fabricate the compound to combine maximum protection with the flexibility needed for easy operation.

The list of operations where the "substitute" material is becoming standard is growing daily. Among the mechanical parts now being fabricated from the polyvinyl alcohol compound are forming rollers, forming press jaw linings, aligning devices (Fig. 8) vibration dampers, shock absorbers, power transmission rings, foot pedal coverings, metal belt pulley facings, etc. It is used in ball mill cover gaskets (Figs. 1–2) where it stands up under solvents which destroyed previous gaskets made from natural or synthetic rubber. Sections of sheet material have been cemented together to make a small parts conveyor belt (Fig. 6) which has proved definitely superior to a belt made of woven wire.

Actually, RCA's rubber conservation campaign has resulted not only in releasing quantities of the scarce material for more direct use by the armed forces, but also in technological advances through the necessity of testing a material which normally might not have been considered.

Credits—Material: Resistoflex PVA.

Tokyo and return

(***Continued from page 43***) cuttings of Army shirt material. This filler gives excellent plasticity to the compound, as well as the high impact strength required.

The assembly and finishing of the housing itself deserve some attention. The molds were designed to assist in assembling the complete housing. The tail end of the housing has threaded studs molded into its open end (see Fig. 3). The nose end of the housing has lugs for fastening the two ends together by means of the studs, using "hex" nuts and washers. In assembly, not only are the studs fastened, but the two parts are solidly cemented together, sanded, roughed and finally painted (Fig. 6). The finished housing has a smooth, streamlined surface with no trace of a parting line (Fig. 2).

The paint used is a special product developed for this application. An alkyd type with great weather-resistant properties, it is first sprayed on (Fig. 7) and then baked. Although it adds some protective qualities to the housing, its primary purpose is to provide a base for the camouflage paint which is applied to the plane before it goes into service.

The completed housing is at present mounted on an aluminum pedestal which in turn is fastened to the fuselage of the plane. Developmental work is now underway with a view to molding the pedestal also of plastic.

Early output of the housings set no world's record. Although the problems of molding the unit had been met and solved, production was barely up to normal expectancy. The all-around difficulty of the job, the many operations of as-

sembly and finishing seemed to preclude any sensational production figures.

Then one day an employee came to work with clippings from a popular magazine showing all types of big bombers. He handed them round, and his surprised co-workers saw plainly on practically all the bombers the housing they were making right there in the plant. Nobody knew about it—and who would have guessed it, especially in these days when almost everything is a military secret? The news spread, and next day—production practically doubled!

The pay-off came when Jimmy Doolittle bombed Tokyo in North American B-25 bombers, because prominently over the fuselage of each of the B-25's is a plastics antenna housing. So an enterprising employee made a poster telling all about it, and set it up in the shop. Last reports indicate that production is now about three times as large as it was when the workers were just turning out an "unknown something."

Credits—Material: Textolite. Molded by Plastics Dept., General Electric Co.

Measuring haze of plastics

(Continued from page 80)

NOTE 2. The photoelectric cell still receives the undeviated fraction of the light but collects only that small portion of the scattered light that is confined to the small solid angles subtended by aperture A at points in aperture B.

(*c*) The difference between the photoelectric current with the specimen at aperture A and at aperture B shall be recorded as a measure of the light scattered, assuming that a linear relation exists between the photoelectric current and the total light incident upon the sensitive element of the photoelectric cell (Note 3).

NOTE 3. The current is practically proportional to the total incident light for no external resistance and the deviation is only slight for the 50-ohm resistance in the microammeter specified.

NOTE 4. Because of a possible lack of linearity of the photoelectric cell, possible spectral deviation of the source and receptor from those specified, and possible geometric inaccuracies, it is advisable occasionally to check measurements with this device with results obtained on an apparatus meeting more accurately the conditions specified in the definition, such as the McNicholas goniophotometer[1] and the Priest-Lange visual reflectometer.[2]

Calculation

6. The haze expressed as a percentage shall be calculated as follows:

$$\text{Haze, percent} = \frac{T_A - T_B}{T_A} \times 100$$

where:

T_A = reading of microammeter obtained with specimen at aperture A, and

T_B = reading of microammeter obtained with specimen at aperture B.

Report

7. The report shall include the following:

(*1*) Thickness of test specimens,

(*2*) Average percentage of light transmission, and

(*3*) Average haze expressed as a percentage.

[1] H. J. McNicholas, "Absolute Methods in Reflectometry," *Journal of Research*, Nat. Bureau Standards, Vol. 1, No. 1, p. 29 (1928) (*Research Paper 3*).

[2] I. G. Priest, "The Priest-Lange Reflectometer Applied to Nearly White Porcelain Enamels," *Journal of Research*, Nat. Bureau Standards, Vol. 15, No. 5, p. 529 (1935) (*Research Paper 847*).

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WANTED: THERMOPLASTIC SCRAP or rejects in any form, including Acetate, Butyrate, Styrene, Acrylic and Vinyl Resin materials. Submit samples and details of quantities, grades and colors or our quotation—Reply Box 508, Modern Plastics.

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10

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